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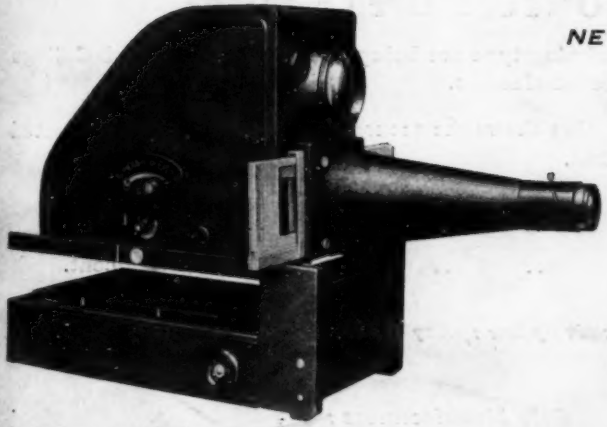

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Archæology in India.

INDIAN archæological remains can be traced back to the Early Stone Age—as far, that is to say, as those of any country in the world. But in spite of the work that has in comparatively recent times been done upon them their interpretation remains, for the most part, almost as great a mystery as ever. And this applies not only to remains belonging to the far distant prehistoric past, but also to most of the temples of historical times, many of them buildings of great magnificence and many still used for worship. Only here and there has a little bit of the curtain been raised, revealing glimpses of intense interest with all sorts of fascinating possibilities beyond.

Starting with prehistoric and protohistoric times, the collections made by J. W. Breeks in the Nilgiri Hills (added to the collections of the Madras Museum as long ago as 1879), by R. Bruce-Foote in South India generally and by Alexander Rea at Adichanallur in the Tinnevelly District and at Perumbair and Pallavaram in the Chingleput District, have long been well known from published accounts of them containing descriptions and illustrations.[1] But such descriptive accounts are only a beginning—a basis for subsequent interpretation. And though the remains are sufficiently abundant no satisfactory basis for such interpretation is yet available. It seems extremely probable however, that as regards the Stone Age the collections recently made by the Yale-Cambridge Expedition to north India will at last provide one. The importance of their work has already been to some extent indicated to readers of *Current Science* in articles by Drs. de Terra and Hutchinson and by Prof. Sahni. From the side of anthropology, hints as to the racial elements that may have to be connected with these and other remains have recently been provided

[1] "An Account of the Primitive Tribes and Monuments of the Nilgiris" by J. W. Breeks (India Museum, London, 1873; Wm. H. Allen & Co.); "Catalogue of Prehistoric Antiquities" by R. Bruce-Foote (Govt. Mus., Madras, 1901); "The Foote Collection of Indian Prehistoric and Protohistoric Antiquities" by R. Bruce-Foote (Govt. Mus., Madras; "Catalogue Raisonne", 1914 and "Notes on their Ages and Distribution", 1916); "Catalogue of Prehistoric Antiquities from Adichanallur and Perumbair" by Alexander Rea (Govt. Mus., Madras, 1915).

by Guha[2] and Eickstedt,[3] the latter drawing on literary and other evidence to attempt a much more detailed but, it is to be feared, also a much more speculative analysis than the former, which is based more exclusively on anthropometrical investigations. Though the conclusions arrived at by these authors are by no means identical, a certain underlying parallelism between them suggests that they at least provide a good basis for further research, which should lead before long to well-established results.

In comparatively recent years archæologists have been startled by the discovery, through excavations in the Indus Valley, of a great civilisation the very existence of which no one had previously suspected.[4] And it now seems probable that this civilisation was by no means confined to the valley in which it was first discovered, so that the familiar term "Indus Valley Civilisation" is likely to prove a misleading name for it. As this civilisation flourished at about the period of transition from the Stone to the Metal Age it gives us a glimpse of life at a time long after that of Palæolithic Man, whose remains are so particularly abundant round about Madras, but probably long before that of the pottery sarcophagus and urn burials found within the city of Madras, as well as in the Coimbatore District and elsewhere, though at present best known from Rea's excavations at Adichanallur and Perumbair. For urn burials seem still to have been customary in the days of early Tamil literature. How much earlier than that they came into use it is as yet impossible to say. Nor do we seem to have any better knowledge regarding the various types of megalithic and cave burials, of which treasure-hunters and cultivators are all too rapidly reducing the greatly diminished number that still remain with their contents intact.

The excavation of Taxila,[5] commenced by General Cunningham in 1863, and continued on modern lines and with much greater thoroughness and understanding than was then possible by Sir John Marshall from about 1912 onwards, has unearthed a sequence of three lost cities of great early renown, of which the first seems already to have flourished in far off mythological times, having been conquered, according to the Mahabharata, by King Janamejaya of snake sacrifice fame. In historical times it would be this city that offered hospitality to Alexander the Great, and in which Asoka ruled for a time as his father's viceroy. On the decline of the Maurian Empire, however, it was captured by Greeks from Bacteria, who shifted their capital to the second city early in the second century B.C. This second city remained the capital, passing under the sway first of the Sakas or Scythians and later of the Parthians, till it was sacked by the Kushans (probably shortly before 64 A.D.) who then founded the third city, which in its turn was laid waste during the fifth century A.D., presumably by the White Huns who conquered the Kushans and ultimately also the Guptas. Taxila thus carries us far on into historical times, and illustrates the many changes and vicissitudes that beset the capital of a frontier state in those early days.

The great majority, as well as the finest, surviving monuments of the early part of Indian historical times are Buddhist. Before the discovery of Mohenjo-daro and Harappa, these were generally regarded as being the oldest surviving Indian monuments of any importance and, both on account of their antiquity and of the marvellous sculpture which many of them showed they have attracted more attention than any other class of Indian monument. One has, indeed, only to mention places such as Sanchi, Buddh Gaya, Larnath, Bharhut, Pataliputra, Nalanda, Ajanta, Karli, Amaravati, Nagarjunakonda and a host of others to realise what a wealth of excavation, description and illustration has been bestowed upon them. But even among Buddhist remains new discoveries continue to be made, as well as among the more scanty Jain remains, many of which belong to about the same period.

Hindu remains are, generally speaking, less ancient than Buddhist, yet much less seems to be known about them. The Archæological Survey and other bodies have, it is true, published finely illustrated monographs on various important temples and

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[2] "The Racial Affinities of the Peoples of India," by B. S. Guha, in "Census of India, 1931, I (3), Ethnographical" edited by G. H. Hutton (Govt. of India Press, Simla, 1935).

[3] "The Position of Mysore in India's Racial History" by Baron von Eickstedt in Vol. I of Ananthakrishna Aiyar's "Mysore Tribes and Castes" (Mysore University, 1935).

[4] "Explorations in Sind" by N. C. Majumdar (Delhi, 1934); "The Indus Valley Civilisation" by E. J. H. Mackay (London, 1935).

[5] See "A Guide to Taxila" by Sir John Marshall (Calcutta, 1918).

groups of temples, such as those of the Deccan,[6] and of the Chalukyan country,[7] or of the Hoysala Dynasty[8] of Mysore or the Pallava Dynasty[9] of the Tamil country, as well as on many lesser groups; but only one serious attempt seems yet to have been made to apply scientific methods of treatment to the development of plan, ornament, etc., that took place in all styles of architecture as time went on, and to use the information thus obtained in the reconstruction of the history of the monuments. This attempt was successfully made by Prof. Jouveau-Dubreuil of Pondicherry, now over twenty years ago, but was concerned only with the kind of temple characteristic of the Tamil country.[10]

The earliest surviving typical specimens of this kind of temple are small monolithic examples which, as was pointed out by Fergusson long ago in his *History of Indian and Eastern Architecture*, show unmistakable evidence in their general structure of the influence of earlier many-storied Buddhist monasteries, such as the celebrated "Brazen Palace" at Anuradhapura in Ceylon, the stone columns of the ground floor of which are still standing, arranged as in a typical early South Indian *mandapa* or pillared hall. Apart from this the ornamentation of these early Tamilian temples is extremely simple, and forms the commencement of a series of steadily increasing elaboration, apparently undisturbed or practically so by any outside influences, which can be traced through the remaining 250 years of Pallava supremacy in the Tamil country, the 500 years of Chola supremacy and the 250 years of Vijayanagara supremacy (during which 250 years this kind of architecture spread all over South India), to a modern period which began in about 1600 A.D.

Thanks to this work it is now possible for a person with a little simple and elementary archæological knowledge, such as anyone of normal intelligence can easily understand and remember, to see for himself when visiting a Tamilian temple at what historical period it is likely to have been built, whether earlier buildings have been incorporated into its structure, and whether alterations or additions of later date have been made; a check has become available by which to test whether buildings recorded in literary records are original or are reconstructions of a later date; and a scientific basis has been provided for the dating of temples for which no literary evidence of the date of construction is available.

Outside the Tamil country such information is equally badly needed but has not yet been provided. In certain districts it might be expected that temples as early as the earliest surviving Tamilian ones might have been strongly influenced by the wealth of decoration lavished on neighbouring cave temples. But Cousens[11] says:—"As the Dakkan temples are found spread over that part of the country in which the bulk of the older cave-temples occurs it would be natural to expect to see some analogy between the architectural details of both, but it is surprising to see how little there is. A greater likeness is found between cave work and that of the seventh and eighth century temples of the early Chalukyas." He specifies, however, certain similarities that do exist and also distinguishes between several northern styles as illustrated by their towers. But, as he does not sufficiently differentiate characteristics connected with locality from those connected with the passage of time, he fails to follow up the clues he has thus provided. From a study of Cousens' monograph on Chalukyan architecture Gravely and Ramachandran[12] have been led to conclude that further field studies would be likely to reveal as definite an evolutionary sequence of ornament in Chalukyan temples and their Hoysala derivatives as Jouveau-Dubreiul has demonstrated in the temples of the Tamil country, but this too remains a mere clue at present.

To sum up—Of prehistoric remains we have descriptions but no understanding; and though there seems to be hope that

[6] "Mediæval Temples of the Dakkan" by H. Cousens (Calcutta, 1931).

[7] "Chalukyan Architecture, including examples from the Bellary District, Madras Presidency" by A. Rea (Madras Govt. Press, 1896); and "Chalukyan Architecture of the Kanarese Districts" by H. Cousens (Calcutta, 1926).

[8] "Architecture and Sculpture in Mysore" by R. Narasimhachar, several volumes, each devoted to one temple (Mysore Archæological Series).

[9] "Pallava Architecture" by A. Rea (Govt. Press, Madras, 1909); "Pallava Architecture" by A. H. Longhurst (Pt. I, Simla, 1924; Pt. II, Calcutta, 1928; Pt. III, Calcutta, 1930).

[10] "Archéologie du Sud de l'Inde" (Musée Guimet, Paris, 1914); and "Dravidian Architecture" (a brief summary only; S.P.C.K. Press, Madras, 1917).

[11] "Mediæval Temples of the Dakkan", pp. 5–12.

[12] *Bull. Madras Govt. Mus.*, III (1, 1934), pp. 14–20, pl. ii.

current work will now very soon result in some degree of understanding of the cultural status of Palæolithic Man in India, the various types of pre-historic Iron Age burials remain as unintelligible as ever, while the daily press bears constant witness to the rate at which these monuments are being rifled. At Mohenjodaro, Harappa and elsewhere the remains of a forgotten civilisation have recently been brought to light; but this civilisation is still very imperfectly understood and excavation by agencies from within the country have practically ceased. For the period of great Buddhist monuments more work has been done than for any other, but a detailed scientific and comparative study of the evolution of these monuments in the country as a whole is greatly needed, and further exploration and excavation still remains to be done. Among Hindu monuments those of the Tamil country are now fairly well understood, though much work there also is still needed in certain directions; but elsewhere no more than the fringe of the subject has yet been touched. Muslim antiquities form a distinct class by themselves and have not been considered above; but among them too it is clear that much further work is required. How are the needs thus briefly indicated being met?

The Archæological Survey of India, and the departments in the Indian States corresponding to it, are naturally the organisations to which one first turns in trying to answer this question. Some of the major results of their excavations have already been mentioned, and to attempt any more exhaustive summary here is neither possible nor necessary. Really their greatest achievement, however, has probably been the much less spectacular one of helping to make possible, through the agency of the Universities and other educational institutions, an ever deepening appreciation of the cultural value of ancient monuments among the better educated members of the population of the country. What has been accomplished in this direction can best be appreciated by reading the address on "The Ancient Monuments of India" delivered by Lord Curzon before the Asiatic Society of Bengal on February 7, 1900.[13] The "gloomy or regrettable features of the picture" there set forth, including as they do the spoliation by picnic parties armed with hammer and chisel of no less a building than the Taj and the narrow escape of this masterpiece on one occasion from complete destruction for the value of its marbles, sound incredible to-day—though the effects of civil war on the antiquities of Spain ought to counteract any easy complacency we may be tempted to feel as to the future.

Like most other departments, however, the Archæological Survey has a severely limited staff. It has never had and can probably never hope to have, in its regular employ, the large number of well concerned men that would be necessary to ensure the proper conservation of the innumerable ancient monuments of this immense country. Much of the execution of any conservation decided upon has to be left to the supervision of some P. W. D. subordinate—probably himself working under pressure of new constructive work or of repairs to inhabited buildings—and so we get the beauty of ancient buildings marred by conspicuous smears of blatantly modern cement, as happened last year on a particularly picturesque and much visited site; or the ends of each uneven line of an Asokan rock edict erased so that they might be readily fitted to the shelter that had been decided on for their protection, a catastrophe that Dr. Spooner arrived only just in time to prevent at Dhauli in Orissa. The line that has been chiselled through the ends of the lines from top to bottom of the rock records the vandalism that so nearly occurred, and will do so for all time. Nor can conservation rightly be the only concern of this department. Investigation is equally important, for without it the monuments conserved cannot be understood. And as in a college or university research is essential to the maintenance of vitality in teaching, and teaching essential to the expression and diffusion of the results of research, so in an archæological department research is essential to the maintenance of vitality in matters of conservation, and conservation essential to a proper attitude towards research. There are, moreover, innumerable ancient sites which, though not requiring conservation by means of any constructional work, are nevertheless in constant danger of destruction by cultivators or treasure hunters—far more of them than any Archæological Survey can ever hope to get protected by sufficient men of adequate integrity and understanding, till such time as they can be scientifically investigated.

We would therefore appeal to all our readers, and to the educated public generally,

[13] *Proc. Asiatic Soc. Bengal*, 1900, pp. 56–65.

to take a keen personal interest in locating and watching over such sites and monuments wherever they may be found, promptly reporting to the concerned survey or state department their location, and any special danger to them which may arise, and seeking the immediate aid of the local Government authorities in any case of urgency.

We would also invite the attention of Government to the severe financial limitations under which the Archæological Survey is at present working. In the introduction to an authoritative review of its work during 1933–34 we read "The era of all-round retrenchment and general economising which the Government of India were forced to inaugurate since the financial stress of the year 1931, continued to be felt very seriously in the Archæological Department. Few branches, indeed, of the many-sided activities of the Government have suffered more from reductions in grants than the Archæological Survey. During the year 1933–34 hardly any excavation was possible, and the amounts allotted for conservation work were, on the whole, about one-fifth of what they had been before 1931." How, we would ask, can the country hope to have properly preserved or studied the priceless monuments that survive as indications of the glories of its past history when its Central Government treats in such fashion the department it has created for this purpose? And what effect is such treatment likely to have as an example to the various Indian States on which rest the responsibility for many other such monuments, some of them of exceptional beauty and importance?

Lastly we would call attention to one specially disastrous effect that is bound to result from the stoppage of excavation work by the Survey, namely, the disappearance of the means of training further excavators. The Survey has in the past had in its service a band of unsurpassed excavators mostly European and mostly already retired. How can they be replaced except again from abroad when such excavation as is carried out is done not by the Survey but by foreign investigators? Yet without excavation research is bound to languish. And without vigorous research the Survey cannot hope to retain the vitality essential to its efficiency.

Diamagnetism and Particle Size.

By Prof. H. Lessheim.

THE investigation of the diamagnetic susceptibilities of small particles obtained by colloidalisation or cold-working has shown that apparently a dependence on the size of the particles prevails. S. R. Rao[1] has advanced the opinion that this is due to the immediate influence of the surface, the area of which increases with decreasing particle size, whereas Bhatnagar[2] and collaborators[3] uphold that the increased surface has no immediate reaction on the diamagnetism; it may come in only in so far as it facilitates hydration, oxidation, carbonisation, etc., which processes on their part falsify the measurements. From this point of view the decrease of the diamagnetism is solely an impurity effect, but no inherent property of the material under consideration. Furthermore, Bhatnagar has emphasised the point that colloidalisation may result in producing an allotropic modification with different crystal structure, which will naturally exhibit a different susceptibility, while cold-working may bring about a severe distortion or even a destruction of the crystal lattice with simialr effects on the diamagnetism.

It is the intention of this report to give a critical survey of the whole subject. If, at present, any conclusions can be drawn, they will be that

(1) the theoretical considerations put forward by S. R. Rao do not support his view;

(2) the immediate effect of an increased surface is by far too small to account for the decreased diamagnetism;

(3) the experimental evidence available is in complete agreement with Bhatnagar's view and excludes S. R. Rao's explanation.

[1] S. R. Rao, *Ind. Jour. Phys.*, 1931, **6**, 241; 1932, **7**, 35; *Phys. Rev.*, 1933, **44**, 850; *Proc. Ind. Acad. Sci.*, 1934, **1**, 123; 1935, **2**, 249; *Curr. Sci.*, 1936, **4**, 572.

[2] S. S. Bhatnagar, *Jour. Ind. Chem. Soc.*, 1930, **7**, 957; *Curr. Sci.*, 1936, **4**, 570.

[3] *Cf.* references 6, 7, 10, 12, 13, 14, 16.

A. The Size of the Particles.

I.

In order to support his opinion that the susceptibility depends directly on the size of the particle, Rao has introduced a classification of the linkages obtaining in metals, in three different types of bonds, which he terms "homopolar", "metallic" and "Ehrenfest-Raman" linkages. The habit of introducing a classification of one's own, and using terms in a meaning different from that for which they are coined, should not be encouraged, particularly after wave-mechanics has been able to give a complete account of the different types of linkages in crystal lattices. Special mention may here be made of Hund's classical paper[4] on the subject.

There is only one way in which a crystal can be built up so as to exhibit metallic properties. This is the case when the number of electrons available (Rao's "extra-ionic" electrons) differs from the number of wave-functions at their disposal, so that a certain state is occupied by only half the number of electrons to be accommodated in it. Then the ground state of the crystal belongs to a continuum of states and any amount of energy, however small, suffices to make these electrons change their positions.

A homopolar linkage of the electrons obtains always when—and only when—their number is identical with the number of states. In this case the ground state is single and has a finite distance from the next continuum; the crystal is an insulator. What Rao calls "Ehrenfest-Raman" binding is not a separate type of linkage at all, but in wave-mechanics a condition satisfied in a number of cases of homopolar linkage, *e.g.*, always in crystal lattices; the term now in general use for it is "non-localisation" of the bonds.

For further particulars Hund's paper[4] may be consulted; it may be mentioned only that transition cases are possible—that of selenium is one of them—especially when layer or fibre lattices are concerned, but the fundamental principles stated above hold always good. So it can easily be seen that Rao's remarks[5] "Bismuth is not a metal in the true sense of the term" and "Graphite is not a metal" are entirely devious. Bismuth and graphite are transition cases on account of their layer lattices; since their ground-states belong to a continuum owing to the splitting of the atomic ground levels on formation of the crystal, they are true metals in the crystallographic sense of the word.

From this it will be seen that Rao's considerations are based on a misconception of the binding conditions in a lattice. Nor has his quoting of Pauli's formula for the paramagnetic susceptibility any definite bearing on the matter under discussion.

II.

We proceed now to consider the influence which an increase of the surface of small crystalline particles can have on physical properties inherent in the crystal structure, *e.g.*, diamagnetism.

A graphite particle of a diameter of $1 \cdot 5 \mu$ contains about $1 \cdot 5 \times 10^{11}$ atoms. The nearest distance which carbon atoms can have in the graphite lattice is $1 \cdot 5 \times 10^{-8}$ cm. Assuming this to be valid on the whole of the surface, assuming further that on the surface the atoms are packed as tightly as possible, the number of atoms on it will be approximately $3 \cdot 6 \times 10^8$. Assuming also that on the surface the diamagnetism breaks down completely, the action of the surface will be about $0 \cdot 0024$ of the total effect. All the assumptions made tend to increase the surface effect. In fact we have nowhere the tightest possible packing, only in very few places of the surface the smallest possible distance, and besides, due to the interatomic bonding forces partly breaking down on the surface, the distances of the atoms are considerably larger than in the interior of the crystal; so the figure $0 \cdot 0024$ derived at is essentially too large and therefore does not actually represent the reduction of the diamagnetism to be expected, but an upper limit for it. On decreasing the size of the particle to $0 \cdot 15 \mu$ the surface effect multiplies by ten, but according to the above, remains still smaller than $2 \cdot 4\%$.

Materially the same holds good in the case of bismuth. Since here the experimental evidence refers to particles of a somewhat larger size, the possible effect of a surface is still less. It is less than $2 \cdot 5 \times 10^{-4}$ for particles of 10μ diameter; and for particles of a smaller diameter the values are found in column 5 of Table I, which is

[4] F. Hund, *Zs. f. Phys.*, 1932, **74**, 1, in abbreviated form also in *Internat. Conf. on Physics*, 1934 (*Phys. Soc. London*), **2**, 36.

[5] S. R. Rao, *Proc. Ind. Acad. Sci.*, 1935, **2**, 249.

TABLE I.

Bismuth.

1 Diameter of particle	2 $-\chi \times 10^6$	3 $-\chi \times 10^6$ after removing oxides	4 Relative decrease of $-\chi \times 10^6$	5 Relative surface effect	6 Part of the metal found oxidised
Macro-crystal	1·08	1·12	0·036	0·0000	
10μ	0·934	1·13	0·166	0·00025	0·05
2μ	0·741	1·14	0·338	0·00125	0·18
$1{\cdot}5\mu$	0·588	1·02	0·475	0·0017	0·30
1μ	0·574	1·05	0·487	0·0025	0·31

compiled from the measurements of Mathur and Verma.[6]

From Table I it is obvious that the decrease of the diamagnetic susceptibility (column 4) is not due to any surface effect of the type invoked by Rao. On the other hand, a comparison between columns 4 and 6 shows that the amount of metal found oxidised is of the same order of magnitude as the decrease of $-\chi$. A complete agreement between the figures of those columns cannot be expected, because several oxides of Bi are formed; the proportions of these oxides vary and need not be equal in different samples. The fact, however, that the figures of column 4 are slightly higher than those of column 6, manifests the influence of paramagnetic oxides of bismuth.

The case of antimony is equally lucid. In full it is discussed later, but in Table III, referring to it, that fraction of the decrease in diamagnetism, which may be accounted for by an increasing surface, is also given and shows again, that it is of an inferior order of magnitude.

Similar experiments on lead have been performed by Verma and Haque,[7] which will be fully discussed later. In this place we have to mention only, that when lead powders of sizes between $0{\cdot}4$ and $0{\cdot}6\mu$ were melted in a vacuum tube the susceptibility remained absolutely constant, whether or not the oxide was removed before enclosing the powder in the tube. This is again conclusive evidence that within the error of the experiment the susceptibility does not depend on the size of the particles, provided the crystal structure is unchanged. Also spongy lead obtained by electrolysing a solution of caustic soda with lead electrodes and lead powders chemically precipitated in different sizes by displacing lead from its salts by magnesium, aluminium or cadmium showed precisely the same susceptibility ($-1{\cdot}22 \times 10^{-7}$) as mechanically powdered lead and the mass metal.

III.

From the above considerations it can be seen that it is certainly not the size of the particle that is responsible for the decrease of the diamagnetic susceptibility. This is corroborated by an interesting piece of evidence. G. R. Levi[8] and later W. Zachariasen[9] have shown that the red and the yellow mercury oxides are structurally identical and that the difference in colour is due to a difference in paritcle size only. If the particle size was in any way decisive of the magnetic properties of a substance the red and yellow oxides should display different susceptibilities, which they however, do not. Mathur and Nevgi[10] have shown that the susceptibility of the red variety is identical with that of the yellow one ($-0{\cdot}24 \times 10^{-6}$).

Another similar example is furnished by the experiments on lead by Verma and Haque[7] already quoted above. Lead crystals obtained under different conditions appear in two distinct varieties, *i.e.*, in the so-called "leafy" form and in the "dark regular" form. They are, however, identical from the crystallographic point of view

[6] R. N. Mathur and M. R. Verma, *Ind. Jour. Phys.*, 1931, **6**, 181.

[7] M. R. Verma and M. A. Haque, *Proc. Ind. Acad. Sci.*, in press.

[8] G. R. Levi, *Gazz. Chim. Ital.*, 1924, **54**, 709; 1928, **58**, 417.

[9] W. Zachariasen, *Zs. f. Phys. Chemie.*, 1927, **128**, 421.

[10] R. N. Mathur and M. B. Nevgi, *Zs. f. Phys.*, in press.

and they show also the same diamagnetic susceptibility of $-1{\cdot}22 \times 10^{-7}$.

B. The Influence of Oxidation.

In most of the cases of apparently decreasing susceptibility it has been proved that the foreign influence which falsifies the measurements is that of a surface coating of oxides and sub-oxides. It is obvious that the proportionately very large surface area of a fine powder is predisposed to all sorts of contamination, so much so that even platinum particles proved to be covered by layers of oxides and oxy-acids.[11]

It is quite clear that a contamination of the particles owing to oxidation is not a mere surface effect which affects only a monomolecular layer of the surface, but that it penetrates deeply into the interior of the particle, often causing an oxide layer of more than $0{\cdot}1\mu$ thickness. Thus not only the surface, but a considerable part of the particle is affected, in the case of antimony (*cf.* Section V) upto as much as 47 % of the total mass, causing an effect of an order of magnitude quite different from that of a mere surface influence. If the ratio of the thickness of an oxide layer to the total diameter of the particle is denoted by χ, the influence of such a layer is given by

$$I = 6\chi - 12\chi^2 + 8\chi^3$$

and with diminishing particle size one obtains

χ	I
0·01	0·059
0·05	0·271
0·10	0·488
0·25	0·875

Furthermore, the oxides formed are often paramagnetic, which brings about a still stronger decrease of the diamagnetism or even a reversion to paramagnetism (*cf.* Section VI) in definite contradistinction to an influence of a mere surface, on which at the utmost the diamagnetism may break down to zero, but cannot invert its sign.

IV. Bismuth.

The diamagnetic susceptibility of bismuth has been measured by numerous investigators, lately in particular by Mathur and Verma.[6] The results are given in Table I. They show that, although there is an apparent decrease with decreasing particle size, the original value is completely recovered, when the oxides are washed off with tartaric acid. It can also be seen that the bismuth removed in the form of oxides amounts to quite a considerable quantity. In order to confirm these results another series of experiments was undertaken,[12] the powdering being done under liquid paraffin and benzene to prevent oxidation as far as possible. The results are tabulated in Table II, showing that now the decrease is much less rapid than before owing to the diminished quantity of oxides formed; on removing also these remnants the original value is entirely recovered, thus proving the susceptibility of bismuth to be independent of the particle size and the apparent dependence to be merely an impurity effect.

Table II.

Bismuth.

Diameter of particle	$-\chi \times 10^6$ before removing the oxide	$-\chi \times 10^6$ after removing the oxide
Macrocrystal	1·27	1·27
1 μ	0·84	1·27
0·7 μ	0·72	1·23

Some more experiments on bismuth will be discussed in Parts C and D.

V. Antimony.

Experiments on antimony have proceeded mainly on the same lines as those on bismuth. The results of Verma and Mathur which appear to be the most conclusive ones in this connection, are given in Table III. The influence of the surface itself has been added in column 4 of that table; although it is here much greater than in the case of bismuth or graphite and certainly above the possible error of the experiment, it is by far too small to account for the rapid decrease of the susceptibility. On the other hand, it is quite clear that decrease is due to oxidation, because the value recovers on removing the oxides with the help of hydrochloric acid. This is particularly striking, when the figures of columns 4 and 5 are added (column 6); the surface effect is actually present, but accounts only for a negligible fraction of the total decrease of diamagnetism, the bulk of which is merely an impurity effect. The last two columns have been calculated on the assumption

[11] S. W. Pennycuick, *Jour. Amer. Chem. Soc.*, **1930, 52, 4621.**

[12] M. R. Verma and R. N. Mathur, *Jour. Ind. Chem. Soc.*, **1933, 10,** 321.

TABLE III.
Antimony.

1	2	3	4	5	6	7	8	9
Diameter of particle	$-\chi \times 10^6$ before removing the oxide	Relative decrease of $-\chi \times 10^6$ against 0·841	Relative surface effect	$-\chi \times 10^6$ after removing the oxide	Sum of the figs. in columns 4 and 5	Quantity of oxygen found	Quantity of Sb oxidised, if in the form of Sb_2O_3	Relative decrease due to Sb_2O_3
Macrocrystal	0·812	0·02		0·841	0·841			
5 μ	0·568	0·32	0·005	0·834	0·839	0·052	0·264	0·469
2·5 μ	0·516	0·38	0·010	0·823	0·833	0·080	0·406	0·260
1·5 μ	0·499	0·40	0·017	0·810	0·827	0·090	0·456	0·292
1 μ	0·498	0·40	0·025	0·805	0·830	0·092	0·467	0·299

that the total amount of oxygen found in the sample existed in the form of Sb_2O_3. Of course, it is not to be expected that this comes anywhere even near the truth; most probably quite a number of various oxides are present, but antimony trioxide is the most frequent one among them, and on making the above assumption we should get at least the required order of magnitude of the effect. The last column shows that this is the case indeed; that the figures are in general lower than those in column 3, points towards the presence of some paramagnetic oxide.

Also this is conclusive evidence that the view put forward by Bhatnagar is correct. It is further corroborated by new experiments of Verma and Haque.[7] Pure antimony, the susceptibility of which was measured and found to be $-0·80 \times 10^{-6}$, was powdered and particles of sizes 0·4 to 0·6μ graded out. These particles showed at first a decrease of the susceptibility to $-0·53 \times 10^{-6}$. Part of this sample was then subjected to hydrochloric acid treatment and sealed in a vacuum tube. The torsion on the magnetic balance was measured before and after melting the sample in the tube and was unchanged in every series of experiments, showing that the particle size did not affect the susceptibility. Another part of the sample was sealed in a vacuum tube without the oxides being removed. After heating to 600° C. and cooling down, the torsion decreased by no less than 11° which means that an oxide had decomposed and a paramagnetic oxide had been formed. This decrease of the torsion remained after melting; but, when the sample was boiled in diluted hydrochloric acid solution and the oxides thus removed, the original value of the susceptibility was regained.

VI. LEAD.

Recent work* on the diamagnetic susceptibility of lead done by Verma and Haque has led to the same conclusions. Lead was carefully and very finely powdered, one part in air, another part under carbon tetrachloride for a very long time (about six weeks for 5 or 6 hours per day). The susceptibility of the sample powdered in air was $+1·42 \times 10^{-7}$ owing to the presence of paramagnetic oxides. After washing the powders in hydrochloric acid, they became diamagnetic with a value of $\chi = -1·22 \times 10^{-7}$ equal to that of the mass metal. The same was the case with the sample which was powdered under carbon tetrachloride. Its susceptibility was at first $\chi = +0·81 \times 10^{-7}$, but recovered to $-1·22 \times 10^{-7}$ after hydrochloric acid treatment. Melting the powders in vacuum did not result in any change of the susceptibility. The amount of oxygen in the samples powdered under carbon tetrachloride was found to be no less than 1·52%.

VII. COPPER.

Apart from earlier work, from which safe conclusions cannot be drawn any more at present, copper in colloidal state was examined by Rao[5] and by Verma and Haque.[7] Rao's experiments will be discussed below (Section IX). Verma and Haque's results are as follows:—

* I am indebted to Messrs. M. R. Verma and M. A. Haque for giving me their results before publication.

Chemically precipitated Cu powder (χ-value identical with that of the mass metal). .. $\chi = -0{\cdot}082 \times 10^{-6}$

Electrolytically deposited Cu powder .. $\chi = -0{\cdot}082 \times 10^{-6}$

Particles of $0{\cdot}4\mu$ diameter graded out by shaking the ungraded powder in benzene .. $\chi = -0{\cdot}082 \times 10^{-6}$

Particles of $0{\cdot}2\,\mu$ diameter obtained by about 30 hours grinding under organic liquids .. $\chi = -0{\cdot}082 \times 10^{-6}$

The same particles of $0{\cdot}2\,\mu$ diameter after HCl treatment .. $\chi = -0{\cdot}082 \times 10^{-6}$

This is again clear evidence that the susceptibility does not depend on the particle size; the lower value for the particles after grinding is an impurity effect due to oxidation which disappears when the oxide is removed by washing the particles in hydrochloric acid solution.

VIII. Other Substances.

Sulphur in the colloidal state was investigated by Gupta.[13] Particles of monoclinic sulphur of sizes $0{\cdot}4\,\mu$, $0{\cdot}6\,\mu$, $0{\cdot}8\,\mu$, $1{\cdot}0\,\mu$ diameter displayed no deviation whatever from the susceptibility of the mass metal $\chi = -4{\cdot}71 \times 10^{-7}$.

Tellurium, both crystalline and amorphous, was the subject of an investigation by G. Singh[14]; after powdering up to 50 hours the various particle sizes of amorphous tellurium ranging between diameters of $1{\cdot}0\mu$ and $0{\cdot}4\mu$ showed no deviation from the mass value $\chi = -0{\cdot}31 \times 10^{-6}$ both before and after washing with hydrochloric acid. The crystalline variety displayed an apparent decrease of $-\chi \times 10^6$ with decreasing particle size, but an exactly parallel decrease of the density of the samples indicated the presence of impurities. After hydrochloric acid treatment the mass values of the susceptibility as well as of the density were completely recovered.

Selenium was examined by Dharmatti[15] who found that on powdering, the diamagnetic susceptibility apparently decreased and eventually changed to paramagnetism. Verma and Gupta[13,16] repeated these experiments on the red and grey varieties of amorphous selenium, the samples being subjected to prolonged powdering under benzene or toluene to prevent oxidation as far as possible. The results are tabulated in the following Table; in each case the value for the mass metal was completely recovered after washing the samples in hydrochloric acid solution.

Table IV.

Amorphous Selenium.

(*a*) Grey variety.

Size of particles	$-\chi \times 10^7$ before removing the oxides	$-\chi \times 10^7$ after removing the oxides
Mass metal	3·01	3·06
$1{\cdot}0\,\mu$	2·89	3·05
$0{\cdot}7\,\mu$	2·73	3·01
$0{\cdot}55\,\mu$	2·69	3·01
$0{\cdot}35\,\mu$	2·69	3·01

(*b*) Red variety.

Size of particles	$-\chi \times 10^7$ before removing the oxides	$-\chi \times 10^7$ after removing the oxides
Mass metal	3·03	3·03
$0{\cdot}6\,\mu$	3·01	3·01
$0{\cdot}35\,\mu$	2·61	3·00

Also these results are conclusive evidence that the decrease of diamagnetism, originally attributed to an influence of the particle size, is an impurity effect owing to a contamination of particles by oxides. In this connection Kohlschütter's experiments on silver sols[17] should be mentioned, only in order to show, how far the presence of a very little quantity of oxidised matter can go in shamming a physical phenomenon. These sols differ in colour according to the glass vessels in which they are prepared; they are from reddish-violet to dark blue in Jena glass and from yellow-brown to rose-red in ordinary soft glass. This variation in colour was neither due to particle size nor to contamination by substances originating from the

[13] I. C. Gupta, M.Sc., *Thesis*, Lahore, 1935.

[14] G. Singh, M.Sc., *Thesis*, Lahore, 1935.

[15] S. S. Dharmatti, *Nature*, 1934, **134**, 497.

[16] M. R. Verma and I. C. Gupta, *Curr. Sci.*, 1935, **3**, 611.

[17] V. Kohlschütter, *Zs. f. Electrochemie*, 1908, **14**, 94.

material of the glass vessel, but solely due to a different content of Ag_2O determined by the adsorption relationship of the walls.

C. Influence of Surface Coatings other than Oxides.

IX. Carbonisation.

As far back as 1837 it was known[18] that carbon or at least carbonised matter will deposit on colloidal particles of bismuth when the powdering is done under water in such a manner that normal air containing carbon dioxide has access to them. This is precisely what Rao[19] has done in his experiments, and the decrease of the diamagnetic susceptibility found by him after carefully removing the oxides can only be due to carbonisation, other sources of facial impurities having been eliminated.

Colloidal particles of copper were prepared by Rao[5] by means of sparking under benzene and propyl alcohol. In this procedure huge quantities of carbon are deposited on the particles, often even as much as to be visible to the unarmed eye, and propyl alcohol is particularly bad in this respect. Since Rao has had no opportunity of decarbonising his samples, the result was the strange effect of increasing diamagnetism with decreasing particle size, brought about by the carbon impurity, the diamagnetic susceptibility of which ($-5\cdot88\times10^{-6}$) is many times higer than that of copper ($-0\cdot082\times10^{-6}$).

In this connection mention may also be made of a paper by Bhatnagar, Mathur and Kapur[20] who investigated the magnetic properties of iron, nickel, cobalt and manganese adsorbed on carbon surfaces and found that due to the adsorption they lose their paramagnetism and become diamagnetic. A similar effect is of course to be expected, when carbon is adsorbed on the surface of colloidal particles of these metals.

X. Adsorption and Absorpion of Gases.

It is obvious that also other films of absorbed or adsorbed matter, especially gases, may have the effect of falsifying the magnetic measurements. Simon[21] found that chabasite ($CaAl_2Si_4O_{12}$) when adsorbing argon, showed a sudden break in the magnetic susceptibility on reaching the ratio of one molecule of argon per one molecule of chabasite, accompanied by a similar break of the iso-thermal curve.

D. Influence of Structural Changes.

As far as changes of the susceptibility are due to a change of crystal structure, we have to distinguish between two different possibilities.

If the change of structure is due to distortion, drawing, annealing, etc., without the lattice arrangement being entirely converted, we have to expect a gradual alteration of the magnetic properties as the corresponding stresses increase. Such influences on macrocrystals have been observed by Bitter[22] and by Lowance and Constant[23] who found that as an indicator of stresses the susceptibility is particularly sensitive. A similar influence in the microcrystalline region appears to be responsible for the dependence of the susceptibility of graphite on the size of the particle (Section XIV).

If, however, the crystal changes directly to a different structure, we have to expect an abrupt, not a gradual, change of the susceptibility on transition. Such changes appear to be much more frequent than hitherto assumed. They can simply be due to the pressure exerted on powdering or cold-working, *e.g.*, amorphous selenium changes easily from the red to the grey-black variety,[24] other changes, *e.g.*, on graphite, have been established with the help of X-radiograms[25]; others have been found out occasionally (*cf.* Sections XII, XIII and XIV) and many more, specially when the change is not indicated by a change in colour or other obvious physical properties, may still be unknown. In any case the importance of satisfying oneself, that no change of structure has occurred, before attributing a physical phenomenon to the influence of mere particle size cannot be emphasised enough.

XI. Lead Oxide.

The yellow oxide of lead has a susceptibility[10] of $\chi = -0\cdot197\times10^{-6}$, whereas the

[18] P. A. V. Bonsdorff, *Pogg. Ann.*, 305, **41**; 1837, **42**, 325; quoted after Mellor, IX, 626.

[19] S. R. Rao, *Ind. Jour. Phys.*, 1931, **6**, 243.

[20] S. S. Bhatnagar, K. N. Mathur and P. L. Kapur, *Ind. Jour. Phys.*, 1928, **3**, 53.

[21] F. Simon, *Zs. Phys. Chemie.*, 1928, **132**, 456.

[22] F. Bitter, *Phys. Rev.*, 1930, **36**, 978.

[23] F. E. Lowance and F. W. Constant, *Phys. Rev.*, 1931, **38**, 1547.

[24] P. V. Schrott, *Phys. Zs.*, 1907, **8**, 42.

[25] G. Asahara, *Scient. Pap. Inst. Phys. and Chem. Res. Tokyo.*, 1922, **1**, 23.

red variety has a value of $\chi = -0{\cdot}211 \times 10^{-6}$. This difference is not due to a different size of the particles, but to a definite change of crystal structure. Kohlschütter and Scherrer[26] have finally established this fact by the X-ray method and confirmed the view of Applebey and Reid,[27] who concluded from crystalline and optical characteristics that the red oxide is uniaxial and rhombic and has a negative optical character, whereas the yellow one is biaxial, rhombic and positive.

XII. Antimony.

Most interesting in this connection is the work of Prins,[28] who has been regrettably misquoted by Rao.[29] The result of Prins's work is not, as alleged by Rao, that the diamagnetic susceptibility of colloidal antimony is smaller than that of the mass metal, but on the contrary, Prins has verified that his "amorphous" antimony is identical with Gore's "explosive" antimony and of a structure different from that of the mass metal; it is therefore definitely not colloidal, *i.e.*, consisting of small particles which are otherwise of the same structure as the mass metal is. Prins has not failed to state expressly that the different value of the diamagnetic susceptibility (not a continuous decrease!) is exclusively due to the altered structure and that this is corroborated by a change in the electron diffraction pattern as well as by the work of Cohen and Strengers,[30] who have directly measured the heat of crystallisation liberated on transition from the amorphous to the crystalline state.

On the other hand, new experiments of Verma and Haque have established the fact that colloidal powder of antimony retains its crystal structure and is not amorphous. Powders of 0·4 to 0·6μ diameter were sealed in a vacuum tube and the torsion in the magnetic balance measured. If they were amorphous, they should change into the crystalline variety at about 120°–150° C. and the corresponding change of the magnetic properties should ensue. In fact heating upto 360° C. did not produce any alteration in the torsion, which proves that no change of crystal structure occurred and the samples had remained crystalline when being powdered.

XIII. Bismuth.

Here comes also the evidence which has lately been collected to show a kind of superstructure in the crystal lattice of bismuth. It is clear that, if a macrocrystal consists of microcrystals, particles of sizes corresponding to that of one or more microcrystals should display physical properties different from those in size below that of a microcrystal. A transition between these sizes would then be equivalent to a certain change of structure and on passing that critical size an abrupt change of the susceptibility may ensue.

Goetz and Focke[31] found that in bismuth crystals infected by foreign atoms these foreign atoms tend to arrange themselves on the boundaries of groups of atoms thus producing surface effects on these microcrystals. Focke,[32] infecting bismuth crystals with polonium atoms, which he then observed with the help of a Geiger counter, found that the polonium had come into a regular order, the atoms arranging themselves in planes distant by 0·54μ parallel to the (111) plane and 0·90μ parallel to the (11$\bar{1}$) plane.

So far magnetic evidence in support of a superstructure in bismuth crystals has not been obtained.

Lane[33] has conducted magnetic experiments on bismuth films of various thicknesses. Although for several reasons[34, 35] his experiments do not prove what they were intended to prove, *i.e.*, that the susceptibility is independent of particle size, which fact has been otherwise established in the meantime (*cf.* Sections II and IV), on checking his results Goetz[34] found that the first few thousand layers of bismuth atoms deposited as film on a plate show rather an amorphous structure entirely different from the ordinary crystal structure assumed by the atoms deposited later. This case seems similar to that of amorphous antimony (Section XII), and a definite change of the magnetic properties is to be expected, if one succeeds

[26] V. Kohlschütter and P. Scherrer, *Helv. Chim. Acta.*, **1924, 7,** 337.

[27] M. P. Applebey and R. D. Reid, *Jour. Chem. Soc.*, **1922, 121,** 2129.

[28] J. A. Prins, *Nature*, 1935, **136,** 299.

[29] S. R. Rao, *Curr. Sci.*, **1936, 4,** 573.

[30] E. Cohen and Th. Strengers, *Zs. Phys. Chem.*, **1905, 52,** 129.

[31] A. Goetz and A. B. Focke, *Phys. Rev.*, **1934, 45,** 170.

[32] A. B. Focke, *Phys. Rev.*, **45,** 219; **1934, 45,** 623.

[33] C. T. Lane, *Nature*, **1932, 130,** 999.

[34] A. Goetz, *Nature*, **1933, 132,** 206.

[35] S. R. Rao, *Nature*, **1933, 132,** 207.

in obtaining particles consisting entirely of such amorphous bismuth.

XIV. GRAPHITE.

Similar evidence for the existence of a superstructure as in the case of bismuth exists also in that of graphite. Also here Goetz[36] thinks the existence of groups of atoms in the crystal possible, mainly in consequence of the work of Krishnan and Ganguli,[37] who found that in a graphite crystal, which has a layer lattice, foreign oxygen atoms arrange themselves between the layers, thus affecting the susceptibility perpendicular to the layers, but not that along the basal plane. This evidence, though in complete accord with our view, appears still to require further corroboration, particularly in view of the fact that the earlier experiments on graphite performed by Paramasivan[38], Vaidyanathan[39], Rao[19] and Miwa[40] do not seem to be sufficiently decisive to serve as basis of a theory.

Apart from this the dependence of the diamagnetism of graphite on particle size seems to have quite a natural explanation, which was also first suggested by Krishnan and Ganguli[37]. Graphite (*cf.* the Introduction) with its layer lattice is a transition case of linkage, the metallic bonds occurring only along the c axis, *i.e.*, perpendicular to the basal plane, whereas in the basal plane the linkage is of a homopolar type. This causes a strong anisotropy of the physical properties, particularly of the magnetic susceptibility, the statements in literature[41,42] of the value of χ_1/χ_2 varying from 1/28 to 1/57. It is further known that on decreasing particle size the distance between the successive layers gradually increases[40], which indicates a weakening of the bonds along the c axis and a corresponding perturbation of the crystal structure in this direction. This would easily explain the decrease in diamagnetism with decreasing particle size, and preliminary measurements of Krishan and Ganguli[37] appear to confirm that χ_2 diminishes with decreasing particle size, whereas χ_1 is indepenent of it.

XV. OTHER SUBSTANCES.

Honda and Shimizu[43] found a change of diamagnetism of copper and tin on cold-working. In this case the crystal structure was forcibly changed or at least severely disturbed, which accounts easily for the effect observed. This is supported by experiments of Rao[44], who has shown that the paramagnetism of the white crystalline tin turns gradually into the diamagnetism of the tin atom, as on progressive powdering, the crystal structure is gradually destroyed. It appears also possible that owing to the pressure exerted on powdering the white tin was partly converted into the diamagnetic grey variety.

On the other hand, when the powders or films to be examined are obtained not by grinding, but by chemical precipitation or by electrolytic or mechanical deposition, small sizes of particles or thin layers of films cannot be expected to have the same structure as the mass substances, due to the proper crystal structure being capable of formation only, when a greater number of atoms are present. Lately, for many metals a large amount of evidence has been collected on this point[45], which cannot fail to demand due consideration in the examination of the magnetic properties of colloidal particles.

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[36] A. Goetz, *Internat. Conf. on Phys.*, 1934 (*Phys. Soc. Lond.*), **2**, 62.

[37] K. S. Krishnan and N. Ganguli, *Curr. Sci.*, 1935, **3**, 472.

[38] S. Paramasivan, *Ind. Jour. Phys.*, 1929, **4**, 139.

[39] V. I. Vaidynathan, *Nature*, 1929, **124**, 762; 1930, **125**, 672; *Ind. Jour. Phys.*, 1930, **5**, 559.

[40] M. Miwa, *Sci. Rep. Tohoku Imp. Univ.*, 1934, **23**, 242.

[41] B. C. Guha and B. P. Roy, *Ind. Jour. Phys.*, 1933, **8**, 345; K. S. Krishnan, *Phys. Rev.*, 1934, **45**, 115.

[42] A. Goetz, A. B. Focke and A. Faessler, *Phys. Rev.*, 1932, **39**, 169, 553; A. Goetz and A. Faessler, *Phys. Rev.*, 1932, **40**, 1053; A. Goetz, *Phys. Rev.*, 1934, **45**, 282.

[43] K. Honda and Y. Shimizu, *Nature*, 1930, **126**, 990; 1935, **135**, 108.

[44] S. R. Rao, *Proc. Ind. Acad. Sci.*, 1934, **1**, 123.

[45] *Cf.* General Discussion of the Faraday Society on "The Structure of Metallic Coating Films and Surfaces", *Trans. Far. Soc.*, 1935, **31**, 1043–1290; particularly:—G. I. Finch, A. G. Quarrel and H. Wilman, *Trans. Far. Soc.*, 1935, **31**, 1051; E. N. da G. Andrade, *Trans. Far. Soc.*, 1935, **31**, 1137.

On the Physical Properties of Crystals.

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THE most characteristic feature of a crystal is its geometrical form. This is not a matter of mere coincidence but is specific with the nature of the internal bondage between the various units in the lattice. The crystal structure thus corresponds to minimum potential energy[1] and is thermodynamically the most stable one. The energetics of crystals have been studied by Born and others[2] and depend on the nature of crystals having (1) heteropolar or ionic lattice, metallic lattice being a special case with electrons as the negative ions; (2) dipole lattice, *e.g.*, the halogen acids; (3) molecular lattice of neutral atoms, *e.g.*, organic crystals. Of these those of class (1) have been studied in detail and the free energy and equation of state have been derived. Thus at absolute zero

$$E = -\frac{K}{\delta} + Ce^{-a\delta} + \frac{C'}{\delta^6} + \epsilon$$

where δ is the lattice distance, K, C, C′ are constants. The first term is the Coulomb energy, the second a repulsive energy term, the third van der Waal dipole-dipole-polarisation energy term and the last null-point energy. Besides these there may be other terms involving higher inverse powers of δ. The above equation may be used for the calculation of free energy, minimum distance of approach, pressure and cohesive force. Thanks to Sommerfeld, Bloch, Peierl and others,[3] the theory of metals has been well established and it has been possible to account for conductivity and other properties on the concept of free electrons, the motion of which is somewhat restricted by 'interaction terms'. Wave-mechanical method has also been applied to complex crystals by Hund, Mulliken, Pauling and others.[4]

The properties of crystals as predicted by theory are not always borne out by experiment and several anomalies have been observed. In fact Smekal[5] has classified these as structure-sensitive, semi-sensitive and insensitive. The last are in accord with theory and these include density, refractive index, elastic properties, specific heat, conductivity, etc. The first are selective and show wide departure from theory. To these belong plasticity, tensile strength and some anomalous dielectric and magnetic properties. The second is intermediate between the first and the last, for instance, conductivity of non-metallic crystals, diffusion, X-ray extinction, etc. According to Darwin,[6] intensity of X-ray scattering alone may serve to distinguish perfect crystals from imperfect ones. The ideally perfect crystals we have for integrated reflection

$$\rho = \frac{\delta}{3\pi} \frac{N\lambda^2}{\sin 2\theta_0} \cdot |F| \cdot \frac{e^2}{mc^2} \cdot \frac{1+\cos|2\theta_0|}{2} \cdot \phi(\tau)$$

and for ideally imperfect ones

$$\rho = \frac{N^2\lambda^3}{2\mu \sin 2\theta} \left(|F| \frac{e^2}{mc^2} \right)^2 \cdot \frac{1+\cos^2 2\theta}{2} \phi(\tau)$$

where

N = Number of crystal units per unit vol.; F = Scattering factor per unit cell; e, m, c have their usual significance; θ = Glancing angle; θ_0 = Bragg angle; λ = Wave-length; μ = Linear absorption coefficient.

Real crystals are usually intermediate between two extreme cases.

The classification due to Smekal is not also rigid. As a general rule structure-sensitive properties tend to become insensitive with rise of temperature, while cold-working has just the opposite effect. Again some apparently sensitive properties become insensitive, for instance, elastic after-effects and dielectric anomaly become structure insensitive in the case of single crystals.[7]

The most marked discrepancy has been observed in the case of plastic deformation, and cohesive strength even for single crystals. It was, however, noted by Joffé[8] that deformation is attended with elongation of Laue spots (asterism) which is attributed to the breaking up of the single crystal into smaller single crystals. It reminds one of the fibrous structure. The destruction limit decreases rapidly with rise of temperature and reaches zero at melting point. The occurrence of lattice curvature may be explicable if we assume with Taylor and Yamaguchi that they have a local character and are due to slip over a limited region.

The discrepancy between the theoretical and observed value of cohesive strength is

still greater. Thus cohesion for rock-salt is only ·4kg/mm.^{2} as compared to the calculated value 300 kg/mm.^{2} Joffé[9] explains this as due to the surface cracks and showed that much better agreement can be obtained if the surface be dissolved out. His observations have been criticised by Polanyi and Ewald.

Structure sensitive properties find no explanation on the theory of ideal solid state. Since ideal crystals are dynamically most stable, real crystals which are imperfect should be pseudo-stable. Pseudo-stable imperfect crystals may occur at ordinary temperature and a sort of secondary structure due to temporary grouping (as in liquids) may also be possible. Low temperature favours the formation of these pseudo-stable configurations which tend to become transformed into the stable ones with rise of temperature. Application of pressure may cause a single crystal to take up a crystallite structure like that of glass. Bridgmann[10] considers that at high pressure lattice itself may be destroyed and the crystal converted into a jelly (which again may be regarded to have a crystallite structure).

Bragg[11] has proposed another ingenious mechanism for the formation of real crystals. The repulsive forces within crystals may be directive and this may lead to asymmetry. With the lowering of temperature the crystal may be subject to strains which may lead to secondary grouping[12] and may also account for the cracks and flaws suggested by Smekal. Other instances of directive forces in molecular physics are not wanting and the above hypothesis may be of interest.

Causes of imperfection in real crystals may thus be reviewed as follows: (1) Mechanical distortion during growth of crystals (flaws, crevices, cracks). (2) Accumulation of stresses detected in metallic crystals. (3) Incorporation of impurities which may be hardly avoided.

The existing theories of real crystals are: (1) Mosaicity due to (i) primary and secondary flaws (Smekal), (ii) surface contraction and secondary structure, (iii) Darwin's theory, (iv) Apparent mosaicity due to lineage structure (Buerger[13]); (2) Griffith's theory of cracks extended by Orawan[14]; (3) Inner adsorption (Balarew[15]). Each of these has its merits and demerits adequately discussed lately. Brief mention of these will now be made.

Smekal considers the ideal lattice as thermodynamically most stable and the flaws and cracks are due to defective growth and presence of impurities. These primary flaws may subsequently give rise to secondary flaws of microscopic dimension either by alteration of temperature or by mechanical effects. Properties of crystals depend on the condition of crystallisation and the anomalies may be readily explained. Structural flaws may actually be detected. The following criticism against Smekal's theory may however be advanced. Variation of density (Goetz), anomalous behaviour in connection with electrical conduction and low tensile strength cannot be quantitatively explained. Dimension and shape of blocks due to flaws are vague.

Zwicky assumes that real crystals are dynamically most stable and Goetz has advanced the following arguments in favour of the group structure: (i) Observation of lines and markings of etch figures, (ii) persistence of paracrystalline structure in liquids a few degrees above the melting point, (iii) difference in behaviour of crystals partly within and partly outside magnetic field, (iv) presence of a critical concentration of impurities, (v) difference in coefficient of expansion measured by optical and X-ray methods, (vi) size effect on certain properties and the existence of critical size. Buerger opines that the above evidences are fallacious and the secondary structure theory is based on misinterpretation of observed facts, all of which can be explained otherwise. The main objection is that theory is based on a erroneous calculation of energy (Orawan), and the ideal lattice is thermodynamically most stable. This is borne out by the fact that mosaicity is not a constitutional property and Ewald and Renniger[16] have been able to prepare ideal crystals of rock-salt which is ordinarily mosaic. Crystallographic considerations are also against the secondary structure hypothesis.

Buerger's theory is based on observational evidences and its origin is not clearly understood. Darwin's theory is also not free from objection. Existence of crystals smaller than the critical size according to Darwin's model and certain difficulties as regards crystal formation may be cited as serious objection against Darwin's theory, which also presumes the crystallite structure for imperfect crystals.

It is interesting to study the effect of impurities on the physical properties. Foreign matters can hardly be avoided during

the growth of crystals and these have been considered responsible for cracks by Smekal and of secondary structure by Goetz. The impurities may either form solid solutions and may go the same space lattice as the mother atoms (Ag in Cu) may give rise to super-lattice as in alloys, form layers or lacunes in crystals or accumulate at the boundary of groups or build up adsorption layers superficially or internally or both. In either case these may disturb lattice, in some cases these may give rise to the formation of minute crystals (as in glass[17]) or distort the crystalline form and change the dimension and form of crystal structure. Their presence may also bring about a re-distribution of energy and hence result in stable forms other than perfect lattice. Removal or rearrangement of impurities may be effected by heat or other agencies and thus lead to a more perfect structure. Cold-working may have the reverse effect. Special care taken to exclude impurities may yield ideal crystals. It may be noted that the inequality in thermal expansion measured by optical and X-ray methods disappears if impurities are absent. Details of the effect of adsorbed matter on crystal structure and properties of crystals will be discussed elsewhere.

In conclusion it may be observed that real crystals are usually different from ideal ones which can be obtained only under special circumstances. Absolutely pure crystals should ordinarily have ideal lattice as the most stable, but pseudo-stable imperfect crystals may also occur at ordinary temperature. None of the existing theories are free from defects. A satisfactory theory is however difficult to propound unless the rôle of impurities is properly understood. In fact the study of imperfect crystals reminds one of colloidal substances on the one hand and of liquids on the other.

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13 Buerger, *Z. f. Krist.*, **89**, 195.
14 Orawan, *ibid.*
15 Balarew, ref. 13, p. 268.
16 Ewald and Renniger, ref. 11, p. 57; Renniger, ref. 13, p. 344.
17 Randall *et al*, *Z. f. Krist.*, 1930, **75**, 195.

India's Mineral Wealth.*

THE excellent account of India's mineral industry prepared by Dr. Coggin Brown should be in the hands of all those interested in the subject whether they be geologists, mining engineers, mine owners or mineral buyers, or those interested merely in the resources of the country. Dr. Coggin Brown's many years of service in India and Burma, with the Geological Survey, is a guarantee of the reliability of the subject-matter, more especially as he was always concerned more directly with the economic side of Indian geology. He displays here that facile ability with his pen, which is noticeable in his past work, to assemble the principle features of each subject in such a way as to make its reading both interesting and pleasurable.

The four parts of the book deal in succession with the mineral fuels, the metals and their ores, other useful minerals, gems and semi-precious stones. Each mineral is taken in turn, its mode of occurrence described, and an outline of each separate industry given, wherever possible. The whole work is nicely balanced. The only criticism which may be made is that the geological map of Bihar and Orissa might have been brought up-to-date.

There is a liberal supply of graphs and tables to illustrate the production of most of the minerals.

The list of selected papers at the end of the volume should be useful to those interested in any particular subject.

J. A. DUNN.

* *India's Mineral Wealth*, By J. Coggin Brown. Oxford University Press. Pp. 335; Rs. 10. With 6 maps and 8 plates.

LETTERS TO THE EDITOR.

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A New Technique of Complementary Filters for Photographing the Raman Spectra of Crystal Powders.

THE discovery of Menzies and Bär that crystal powders yield Raman lines even so as large single crystals themselves was a step in advance in the experimental study of the Raman spectra of solids. The chief handicap of this method when using the unfiltered radiations of the mercury arc as the exciting source, is the heavy continuous spectrum which causes rapid fogging of the photographic plate so that, in general, only the more intense lines are distinctly recorded. Attempts have not been wanting to devise a suitable technique to get over this difficulty, and mention may be made in this connection

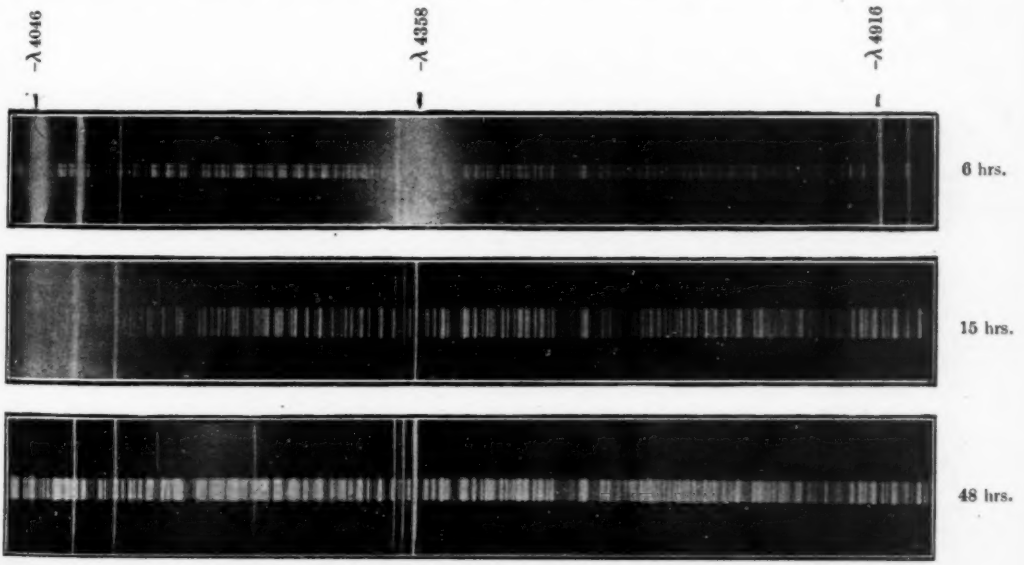

Fig. 1.

to the work of Krishnamurti on the Raman spectra of crystal powders. It is nevertheless true to say that the measure of success achieved has not been very considerable.

Recently, while engaged in the investigation of the Raman spectra of some compounds of the ammonium group, I have found that by a slight modification of the usual powder method, it is possible to record the Raman spectra of solids with as much clarity and completeness as in the case of liquids. In principle, it consists in employing a strictly monochromatic beam for excitation, and absorbing this particular wave-length from the scattered light before the latter enters the spectrograph. Under the circumstances, in the ideal case, only the Raman lines would be recorded on the plate, and if the substance is free from fluorescence, the exposure can be prolonged to any extent to record the complete spectral details.

In practice, these conditions are realised to a fair degree by the use of a concentrated solution of iodine in CCl_4 to filter off the incident radiation of the mercury arc, and a cell of sodium nitrite ($NaNO_2$) solution in front of the slit of the spectrograph. The exciting line in this case is λ 4046 of the mercury arc, and is subsequently absorbed by the solution of $NaNO_2$. The necessity for two such complementary filters will be evident from the photographs reproduced in Fig. 1, which are respectively—

(*a*) the Raman spectrum of $NH_2OH.HCl$ (crystals) using the unfiltered radiations of the mercury arc ;

(*b*) the Raman spectrum of $NH_2OH.HCl$ (crystals) using the mercury arc light filtered by a solution of iodine in CCl_4 ;

(*c*) the Raman spectrum of $NH_2OH.HCl$ (crystals) using the mercury arc light filtered by a solution of iodine in CCl_4, and placing a cell of $NaNO_2$ solution in front of the spectrograph slit.

The duration of exposure in each case is also given against the corresponding picture. The present work clearly shows that the major cause for the fogging of the plate in the usual powder method, is not the continuous spectrum of the mercury arc light itself, but is the general illumination in the interior of the spectrograph when the intense exciting line is allowed inside.

The results of the study of the Raman spectra of some typical solids by the new technique will appear shortly in the *Proceedings of the Indian Academy of Sciences*.

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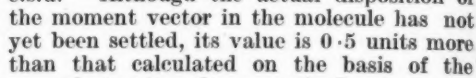
September 7, 1936.

Structure of Cumarin.

IN the course of a study of the dipole moment of a series of pyrone compounds the moment of cumarin in benzene as solvent and at 20° C. is found to be $4 \cdot 51 \times 10^{-18}$ e.s.u. Although the actual disposition of the moment vector in the molecule has not yet been settled, its value is 0·5 units more than that calculated on the basis of the normal structure for cumarin I. As in the case of γ-pyrone,[1] this increase can be explained as due to an excited state II with which the normal molecule is in resonance.



I II III

The excited phase of the molecule will account for the several addition products of cumarin with metallic salts, the greatly depressed reactivity of the carbonyl group, and also the reduced reactivity of the ethylenic link in the pyrone ring. It can be easily seen that the excited state is but a modern version of the old Clayton[2] formula III, and is in consonance with the Robinson hypothesis of electromeric shift from $\diagup O \diagdown$ to $C = O$ such as occurs in the $-COOH$ group.

Full details will be published in the *Proceedings of the Indian Academy of Sciences*.

M. A. GOVINDA RAU.

Department of Physics,
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Bangalore,
September 14, 1936.

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Viscosity of Air and Electronic Charge.

THE value of "e", the electronic charge, as found by Millikan in his famous oil-drop method is rather low as compared to that determined by X-ray methods. This value is ascribed to the uncertainty about the value of the viscosity coefficient of air. The value of the viscosity of air as measured by Kellström[1] recently, is higher than that taken by Millikan in his calculations to determine the value of "e". When Kellström's value of η, the viscosity coefficient of air is substituted in Millikan's data, a higher value for "e" is obtained which is nearer to the value of "e" as found by other methods.

We have measured the value of η by a modified form of Wagstaff's method[2] in which air flows through a capillary tube. Our value of η is higher than that used by Millikan and it is interesting to note that our value of η is closer to Kellström's value, who has used the rotating-cylinder method. Thus the two independent methods give values for η which are higher than that used by Millikan.

The value of η (a mean of 61 readings) as found by us is $1855 \cdot 5 \times 10^{-7}$ c.g.s. units at 28° C. This reduces to $1830 \cdot 8 \times 10^{-7}$ c.g.s. units at 23° C. and to $1816 \cdot 2 \times 10^{-7}$ c.g.s. units at 20° C.

The following table gives the values for η at 23° C. as determined by different observers and the corresponding values of "e", the electronic charge, using Millikan's data.

Observer	Method used	$\eta \times 10^{+7}$ c.g.s. units	$e \times 10^{+10}$ e.s. units
Gilchrist[3] (1913)	Rotating-cylinder	1825·7	4·7822
Rapp[4] (1913)	Capillary tube	1822·7	4·7704
Millikan[5] (1913)	Rotating-cylinder	1822·5	4·7704
Harrington[6] (1916)	Rotating-cylinder	1822·6	4·7704
Kellström[7] (1935)	Rotating-cylinder	1834·8	4·8180
Kellström[1] (1936)	Rotating-cylinder	1834·9	4·8180
Authors	Capillary tube	1830·8	4·8022

A detailed report of these experiments will be published shortly elsewhere.

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August 29, 1936.

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[7] Kellström, *Nature*, 1935, **136**, 682.

Synthesis of 5 : 6-Benzohydrindene.

WITH the expectation of finding out a new method for the synthesis of 1 : 2-*Cyclo*-penteno-Phenanthrene, which is the parent C-skeleton present in the sterols and bile acids, the following preliminary attempt in that direction was made starting from hydrindene. The scheme though failing in the original project is undoubtedly interesting in its application for the synthesis of polycyclic carbon ring compounds.

Succinic anhydride condensed with hydrindene in presence of anhydrous aluminium chloride giving mainly γ-Keto-γ-5-hydrindyl-*n*-butyric acid (m.p. 123–124°), this on reduction by the Clemmensen method gave γ-5-hydrindyl-*n*-butyric acid (m.p. 56°) which on cyclisation with 85% sulphuric acid gave 6: 7-Cyclopenteno-1-Keto-1: 2:3:4-tetrahydronaphthalene (b.p. 167°/6 mm.). This Keto compound was reduced by the Clemmensen method to 6 : 7-Cyclopenteno-1 : 2 : 3 : 4-tetrahydronaphthalene (b.p. 125–126°/6 mm.), which on Selenium dehydrogenation at 300–340° yielded 2 : 3-Cyclopentenonaphthalene, *i.e.*, 5 : 6-benzohydrindene, m.p. 94°. Picrate golden yellow needles, m.p. 120–121°. The method is being extended for the synthesis of polycyclic hydrocarbons. The experimental details will be published in a chemical journal in due time.

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August 21, 1936.

Amino-Acid Dehydrogenases in Germinating Seedlings.

THE importance of asparagine and glutamine in the nitrogen metabolism of the germinating seedling was established by the classical researches of Schulze and confirmed by the later work of Chibnall and others. It is usually assumed that these amides are formed by the combination of the corresponding acids with ammonia arising from the deamination of other amino-acids, though little is known of the mechanism of such deaminisation.

Recent work, notably that of Krebs[1] and Bernheim and Bernheim,[2] has demonstrated the part played by dehydrogenases in oxidative deaminisation in animal tissues; Krebs[3] and Weil-Malherbe[4] have postulated two separate mechanisms involving deaminases which would lead to the formation of glutamine in such tissues, though the presence of the latter in the animal organism has not yet been definitely demonstrated except in certain detoxications. It is obviously of importance to ascertain if there is any evidence of the existence of similar mechanisms in germinating seedlings in which amide synthesis is a well-established fact.

Dehydrogenase activity was tested for by the Thunberg's methylene blue technique. M/10 solutions of the following amino-acids were used as substrates: glycine, *l* (+)-alanine, *l* (−)-leucine, *l* (−)-histidine, *l* (−)-tyrosine, *l* (−)-aspartic acid, and *l* (+)-glutamic acid. The experimental material was prepared by grinding up two days' old seedlings with 0·87 % dipotassium phosphate, pressing through muslin and centrifuging the extract.

It was found that the only amino-acids that have a definite accelerating action on the reduction of methylene blue by the extracts are glutamic acid and alanine. The following table shows the results of a typical experiment with the seedlings of *Phaseolus mungo* (green gram). The times given are for the decolourisation of 0·5 ml. of a 1/5000 solution of methylene blue by 0·5 ml. of the plant extract in the presence of 0·2 ml. of M/10 amino-acids.

Substrate added	Period of decolourisation
0.2 ml. Glutamic acid ..	7 mins.
0.2 ml. Alanine ..	10 mins.
No substrate ..	16 mins.

The effect of alanine is not sufficiently marked, the Thunberg factor "I" being less than one, to infer with certainty the existence of a specific dehydrogenase for this amino-acid. Even the glutamic acid dehydrogenase is limited in its distribution, it being found only in three out of the seedlings of several species examined, *viz.*, in *Phaseolus mungo* (green gram), *Phaseolus radiatus* (black gram), and *Pisum sativum* (pea). From extracts of two day old seedlings of these species, the dehydrogenase can be obtained in cell-free solution by filtration of the centrifuged extract through paper pulp. The optimal reaction for the action of the enzyme is pH 7·8, while below pH 5·8 it has no activity. Manometric experiments show that the enzyme is capable of oxidising glutamic acid in the presence of molecular oxygen also. The products of oxidation as well as the connection of the enzyme, if any, with glutamine formation are being investigated.

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Chepauk, Madras,
August 17, 1936.

[1] Krebs, *Biochem. J.*, 1935, **29**, 1951.
[2] Bernheim and Bernheim, *J. Biol. Chem.*, 1932, **96**, 325; 1934, **106**, 79; 1934, **107**, 275.
[3] Krebs, *Biochem. J.*, 1935, **29**, 1620.
[4] Weil-Malherbe, *Biochem. J.*, 1936, **30**, 665.

Relative Digestibility of Caseins in their Artificial and Natural Environments.

AN ultra-microscopic study of milks from various species of animals reveals large differences in the dispersion of casein particles. Of the milks examined so far the buffaloe's milk has the lowest dispersion of casein while that from the ass has its casein dispersed to the highest extent. The albumin content of a milk generally increases with the extent of dispersion of its casein particles, the higher the dispersion the greater the albumin content. Ass's milk possesses the highest amount of albumin, thereby offering effective protection to the highly dispersed casein particles.

From the point of view of digestion it is reasonable to expect a higher digestibility in the case of milks which exhibit a higher dispersion of their proteins. A comparative study of the *in vitro* digestion of milks from the cow and the ass, has shown that ass's milk is about one and a half times more digestible than that of the cow. It was of interest to determine if the caseins prepared from their respective milks continued to

maintain their digestibilities when they were redispersed in an artificial environment (phosphate buffer). In the course of this experiment, many interesting points of difference between the two caseins, revealed themselves. As compared with cow's casein it was difficult to redisperse the casein from ass's milk in the M/15 phosphate buffer (pH 7·7); and it is therefore clear that although the same buffer and the same concentration of the two caseins were used for the digestion experiments, the substrates were, therefore, not dispersed to the same extent. Ass's casein is much harder and denser than cow's casein prepared and purified under the same conditions. The casein particle in ass's milk exhibits a powerful tendency to aggregate and the exceptionally high ratio of albumin to casein (1 : 2) is Nature's provision to protect the highly dispersed casein particles and keep them from coalescing.

It has been found that the rate of digestion of albumin from ass's milk is only a fifth of the rate at which ass's casein is digested. This circumstance is of great importance from the point of view of digestion of the casein particle since the albumin continues to offer colloidal protection until the casein attains a reasonably advanced stage of degradation.

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September 14, 1936.

An Ageotropic Mutation in X-Rayed Rice.

IN the course of studies on the mutations obtained in X-rayed rice, a plant with a prostrate habit was isolated in the second generation of plants raised from one of the pure lines, Co. 4, the dry seeds of which had been exposed to X-rays for one hour under a Coolidge tube with copper anti-cathode operated at 53 kv. and a tube current of 10–11 m.a. at a target distance of 17 cm. without filter. Only a few seeds were obtained from this plant as by the habit of the plant, most of the seeds had fallen into the field. The seedlings raised from the seeds in the usual swampy seed-bed were of two kinds, the natural erect ones and the prostrate ones like the parent. In the prostrate type the inclination of the shoots did not present any regularity as it was in all directions. The seedlings were later transplanted in regular plots. Generally rice seedlings grow erect after they strike root, which will be in about a week after transplantation. In this particular progeny it was found that while many of the seedlings were growing in an inclined direction, some were like the normal seedlings growing erect. The segregation was a mono-hybrid one, indicating the dominance of the prostrate habit.

	Observed	Expected (3 : 1)
Prostrate ..	28	30
Erect ..	12	10

$$\frac{\text{Dev.}}{\text{S.E.}} = 0{\cdot}72.$$

These prostrate plants are unique and are different from the type described by Ramiah (1930) where the prostrate habit of the plant was due to the spreading nature of the tillers. During the heading time, the tillers bend at the nodes and become erect and later on again assume a spreading habit at maturity. The type described here, on the other hand, presents an appearance of a plant completely or partially lodged without any bending or curving in any of the nodes against gravity. It resembles the 'lazy' plant described by Jenkins and Gerhardt (1931) in maize where the prostrate nature of the plant was suggested by Eyster (1934) and later on by Overbeek (1936) as due to the stem being '*ageotropic*' or gravitationally indifferent.

Seeds of one of this prostrate plant and of the normal Co. 4 strain from which this mutation arose, were sown in a line centrally, each in a separate pot. As soon as the tip of the seedlings were visible above the surface of the soil, both the pots were tilted and kept in a horizontal position with the soil surface vertical. While the seedlings from the prostrate plant grew horizontally, the normal seedlings curved up and grew vertically (Fig. 1). In another set both the pots were hung inverted, top downwards soon after germination. The prostrate plant progeny grew downwards while the normal seedlings bent flat in their attempt to grow vertically upwards against gravity.

Fig. 2 shows the same control and prostrate progenies sown in a pot and allowed to grow without any change in the position of the pot. While the seedlings of the control are erect, those of the prostrate show inclination to the vertical. This inclination is more enhanced if these are raised in wet seed-bed.

The progeny of all the plants both erect

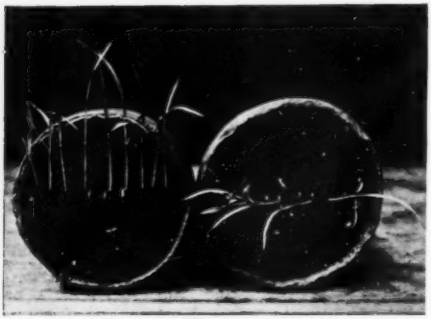

Fig. 1.

Normal Seedlings. Ageotropic Seedlings.

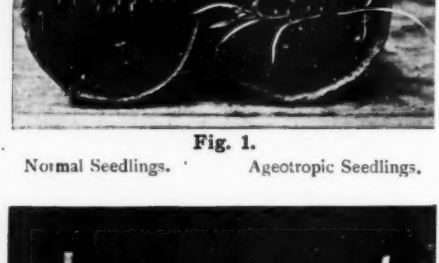

Fig. 2.

and prostrate are being grown this season for confirmation of their behaviour in inheritance. While in the case of maize, the gene for *'lazy'* is a simple mendelian recessive, in this case with rice it appears to be a simple dominant. The fact that parallel mutations are in some cases dominant and in other cases recessive is still mysterious and requires investigation. Studies on the response of this ageotropic mutant to light are under progress.

Though the mutation described above was derived from the material that was subjected to X-rays the possibilities of such a mutation occurring independently in nature are not entirely ruled out but so far as the authors are aware no record has been made of such a mutation occuring in rice.

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Coimbatore,
August 17, 1936.

Eyster, W. H., *Bibliographica genetica*, 1934, **9**, 215.
Jenkins, M. T., and Gerhardt, *Ag. Expt. St. Iowa, Stat. Coll. Bull.*, 1931, **138**, 123.
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Visibility of Ultrasonc Waves in Liquids.

THE theory regarding the visibility of ultrasonic waves as given by N. S. Nagendra Nath, which is under publication in the *Proceedings of the Indian Academy of Sciences* for September, has been verified by me in this laboratory.

The earliest observations were made by Hiedemann and his collaborators at Köln, and later by Bär at Zurich. Parallel monochromatic light falls on one face of a cell containing a liquid through which ultrasonic waves of frequency $7{\cdot}164 \times 10^6$ c./s. are passed. On the opposite face a microscope is placed, focussed on the optical grating formed by the sound waves. Stationary waves were used throughout.

The grating pattern of the field was obtained for one position very near the cell and the pattern repeated itself on moving the microscope through a distance corresponding to $d = \frac{\lambda^{*2}}{2\lambda}$ where λ^* and λ are the wave-lengths of sound and light respectively. Even at multiples of this distance, there was repetition of the pattern. This is in conformity with the theory put forward by Nath for the periodicity of the phenomenon and observed for the first time.

It was also noticed that at exactly half the distance required for the pattern to repeat, the fringes observed were doubled. At all other positions of the microscope only a constant intensity of the field was observed. This periodicity of the phenomenon gives yet another method for determining the velocity of sound in a liquid very accurately, for if we know d and λ, λ^* and hence v the velocity of sound can be calculated from the known frequency of vibration of the quartz. Thus for the frequency $7{\cdot}164 \times 10^6$ c./s. the velocity of sound for the following liquids were obtained:

Benzene	..	1302 m./s. at 25° C.
CCl_4	..	918 m./s. ,,
m-xylene	..	1320 m./s. ,,
and Anisol	..	1441 m./s. ,,

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Bangalore,
September 22, 1936.

REVIEWS.

Dielectric Phenomena in High Voltage Cables. By D. M. Robinson. (Chapman & Hall, London), 1936. Pp. 137. Price 15*sh.*

This book deals with what must have appeared to be one of the most obscure subjects ever confronting applied science. It does not deal "with the art of the cable-maker nor with the processes involved" which is rather surprising in spite of the title but the subject-matter forms a fascinating account of the problems arising in connection with paper insulated cables and the way in which the different methods of failure have been identified and classified, and the various causes of failure have been brought to light.

Perhaps, the most arresting feature of cable-making is the multitude and complexity of the problems arising from such an apparently simple contrivance as a conductor insulated with paper and sheathed with lead and the enormous amount of investigation work arising from them. This work has invaded all fields of science such as the metallurgy of lead and copper, the chemistry of rubber and oils while an idea of the extensive detail of the investigators may be gleaned from the extent of work done on wire-drawing alone—under this heading has been studied the deformation and change of stress distribution with the number of passes through the die, the life of the die in connection with the lubricant used and, unless we are mistaken, the discovery of Boron Chloride, the hardest material known, is a by-product of cable research.

The production and application of the armouring alone has led to an extraordinary amount of work in the production of flawless sheaths, methods of excluding oxide, corrosion effects, machines for applying the sheath and to such abstruse subjects as atmospheric action on fatigue phenomena.

With regard to the dielectric the main problems have naturally centred round the different modes of breakdown which may be divided into two main classes, the "carbon track" breakdown and failure due to "thermal instability". The former consists of a carbon track (treeing) which slowly forms in the course of a long time from a point near the conductor and takes an oblique path towards the sheath. It has been fairly well established that it has its origin in the ionisation which takes place in any small space (technically termed "void" but this does not necessarily signify an empty space) near the conductor which produces some carbonisation due to oxidation of the oil and the spread of which the paper alone is not able to stop.

The other type of failure is due to the rate of heat production by the dielectric loss in relation to the capacity of the cable to dissipate the heat. If then the power factor of the dielectric increases with temperature the conditions may be such that the temperature continues to rise until the insulation becomes charred and breakdown takes place. This type of fault is characterised by a small hole passing radially from the conductor to the sheath, the condition after breakdown depending on the power of the fault arc. In this connection the heat conducting properties of the soil or other surroundings of the cable frequently outweigh those of the cable itself.

In addition to these two distinct causes there are, as one might expect, mixtures of the two, the heat involved by the tracking mechanism may be sufficient to cause local thermal instability. This probably made the original separation into the two classes very difficult. This classification leaves out of consideration failures of the type called "Disruptive" or by the more accurate name "Puncture Breakdown" as this type clearly stands in a class by itself.

An enormous amount of ingenuity has been displayed in the experimental work on cables not the least being the production of "arrested failures" and the testing technique employed which, in view of the long time element involved in full scale testing must be made to imitate, by shorter period tests, the effects produced in service. The Schering bridge which was first applied to cable investigation about 1922 does not give information about definite localities but its use has been of great service in cable manufacture and good results followed immediately from the first applications of it. The Magneta Wax Test has been of the greatest service in making visible the effects of tracking by showing up the wax residue resulting from the oxidation of the oil.

Again, clever testing technique has enabled two workers recently to establish that power factor and oxidation considered radially through the dielectric follow a U-shaped curve.

Since the carbon-tracking failure results from ionisation it might be expected that the gas pressure and kind of applied voltage whether d.c., a.c. or surge and the frequency in the case of a.c. would have considerable effects on the result.

Recent work on the subject includes the fundamental properties of paper as a dielectric once again and of paper in relation to moisture content while the dielectric loss in paper and oil separately and the peculiar difference between their separate properties and those of the combination are matters of continuous work.

Apart from the practical utility of the book to cable users in general the chief interest of the book to the ordinary man of science is twofold, first in the fact that so much of the work is pure physics (or would be except that the final object of it is industrial production) and secondly the comparison between modern theories, particularly his own and the author's, on the behaviour and properties of dielectrics and their application to practice. In spite of the fact that the author acknowledges only meagre benefit from the vast amount of attention by scientists to laboratory dielectrics one cannot help but feel that the cable makers must have profited to quite a considerable extent from the general ideas enunciated by the theoretical physicists. On the other hand of course pure scientists are not likely to impose on themselves such limitations as the necessity for rolling on a drum of 5 or 10′ diameter which, in the case of a cable of about 2″ diameter, is a serious matter indeed. In addition the interest of cable users will centre round the author's remarks on the routine testing of cables. Often it happens that one of the greatest difficulties of manufacturers is to persuade the purchaser to accept tests which are suitable to the occasion, which are sufficient for the purpose and which still impose no permanent injury on the apparatus.

An interesting item of news in connection with this subject is the recent installation in Paris of a cable for 220 kilovolts and 160,000 k.v.a.

Our Enemy the Termite. By T. E. Snyder. (Comstock Publishing Co., Ithaca, New York), 1935. Pp. xii + 196. Price 3 dollars.

For what is probably the first time, co-ordinated information about the termites has been presented in this book with the forbidding title. So many fallacies have crept into popular accounts of these animals that the time has arrived for scientific truth to step in and check their growth and spreading. The author who has been associated with the Bureau of Entomology, United States Department of Agriculture, has studied termites for over twenty-six years and has collected valuable information about their habits, their structure, their distribution and their life-history.

Very naturally, the termites of the American continent have come in for fuller treatment and the author expresses the encouraging hope that the undiscovered species of termites are far greater in number than those described so far. The book can be neatly divided into two sections, the first, of six chapters, containing information about the termites from a biologist's point of view, while the second, of four chapters, is in itself, a treatise on the economic aspects of termite life.

The original home of the termite was probably the jungle and the author holds man responsible for their advent into towns and civilised habitations. Extensive deforestation, conversion of thick jungle to form plantations and acquirement of large tracts of virgin forest for man's use, have resulted in ousting the termite from its natural habitat so much so that it threatens to be one of man's serious insect pests. One would be greatly fascinated but deeply perturbed at the extremely catholic taste of termites, practically every article under the sun forming the object of their attention.

A refreshing thing is to note that the author is not the type of abstract scientist so common all over the world. In a problem of this type, the close bearing of termite life with that of man's, is the first to be recognised and Dr. Snyder has devoted much space and attention to constructive methods of control and remedy of this pest.

It is impossible to make the book more interesting than what it is. Dr. Snyder has many stories to tell of the great hardship he has endured during the course of his twenty-six year study but he has come

unscathed,—indeed, has brought out a work of supreme value to the naturalist, to the building contractor, to the forest engineer and to every citizen. The numerous figures illustrating the book are eloquent proof of the thoroughness of the author's efforts and the usefulness of the work is considerably heightened by a glossary and an index.

B. R. S.

Survey of India Geodetic Report for 1935. (Published by the Director, Geodetic Branch, Survey of India, Dehra Dun), 1936. Pp. 101 + xxxvii with 20 charts. Price Rs. 3 or 5*s*. 3*d*.

The volume under review is a report of the activities of the Geodetic Branch of the Survey of India during the year 1934–35.

The book covers a wide and varied field. Chapter I is on Triangulation containing a report on the measurement of primary series of triangulation carried out during the year, to replace the Assam Valley Series. In all, observations were made at thirty stations, use being made of the old stations in the Assam Valley, with two new stations in the Mikir Hills and a few in the administered Naga Hills. At each station, two days and a night and more often two whole periods of 24 hours were found necessary for carrying out the observations. Chapter II deals with an account of the progress made on high precision level net. The precise levelling was also done on the Bagaha-Sironj line with a view to correct the main line of levels affected by the Great Bihar Earthquake to Sironj, on the stable part of the Peninsula. But levelling was carried only as far as Ghazipur, the heights of Bench Marks at Bagaha showing a rise of 1¼ to 1½ feet as determined just after the earthquake in 1934 and from Gorakhpur to Ghazipur showing a rise of about ½ foot. But it will not be possible to determine what changes in levels have taken place prior to the completion of this line of levels. Chapter III is a report on the Deviations of the Vertical. Both Components of the deviations of the vertical were measured at 107 stations in Baluchistan and between Orissa and Rajputana. The meridional Component of the deviation was also measured at 34 stations along a line from near Hyderabad (Deccan) to Agra. This work completes the main east to west geoidal section across India and Burma and the north to south section in India. Revised Geoidal Charts have been prepared. Chapter IV deals with the Gravity Survey made at 33 stations extending from north of Bombay to Cutch and Rajputana; the observations consisting of 3 sets of duration from 6 to 10 hours each, between time signals. The results add considerably to our knowledge of the tectonic structure of this part of the Peninsula. Chapter V is devoted to an account of the Geophysical Survey in Bihar. Gravity observations with the pendulum, showing only the main tectonic downwarps and upwarps was found unsuitable to more detailed investigation necessary for the determination of the configuration of the bed rocks underlying alluvium. Hence a preliminary investigation was undertaken using both gravimetric (torsion balance) and magnetic methods of geophysical exploration over the same line of country from Nepal boundary due south to just west of Motihari. The result of the survey indicates the possibility of successful delineation of the buried features which is essential to adopt methods of protection against earthquakes. Work done in the computing office and in the Tidal Section is dealt with in Chapter VI. Apart from the preparations of the usual Tide Tables for the Indian Ocean for the year, at the request of the International Association of Physical Oceanography, the monthly and yearly values of mean sea-level at Bombay from 1878 (the first year of available data) to 1930 have been computed by the Tidal Section. The data do not show any progressive change of sea-level relative to the land at Bombay during this period. The results of the International Commission are likely to be of considerable interest. Chapter VII is an account of the work done at the Dehra Dun Observatory. The usual bi-weekly observations for time were made during the year with the motor and shutter transits. The short and Riefler Clocks have been equipped with batteries of Edison Soda Cells with a view to stop failures or irregularities due to battery charges. The regular magnetic, meteorological and seismographical observations have been carried out as usual. The last chapter contains some notes on the changes of level in Bengal by Mr. B. L. Gulatee, M.A. (Cantab.). The question of rise of level in Bengal as compared with Calcutta is considered afresh in the light of levels from Karachi. Rise of Benares is only indicated by lines from Howrah; all other lines available so far, tend to show that both Benares and Agra

have remained stable. The conclusion from an examination of the various level nets is against the supposed rise.

Every chapter in the volume is accompanied by a number of charts and tables prepared with great care. Special attention has to be drawn to some of the sections which are of outstanding interest. Geophysical Survey in Bihar is a pressing need and full of possible future utility in that, that it may throw light on the needs of the locality for protection against subsequent earthquakes. The question of constancy of sea-level is also of considerable interest. Colonel Walker, Superintendent, Great Trigonometrical Survey, has long ago referred to a correlation between mean sea-level and barometric pressure and now further attention has been drawn in the *Comptes Rendus de l' Academic des Sciences* to the connection between mean sea-levels and meteorological conditions by Mr. M. Jean Legrad who has shown a relationship between mean sea-level in the Mediterranean Sea and rainfall in Abyssinia. We learn from the Report that he is now being supplied with the mean sea data relating to Aden and other ports and the result of his researches will no doubt be awaited with interest.

The volume deserves a wide circulation among surveyors, engineers and other scientists and will surely be a good addition to any library, containing as it does, a mass of valuable information, the result of a year's strenuous activity of the Geodetic Branch of the Survey of India.

C. G.

Statistical Methods and their Application to Agronomy—A Bibliography. Compiled by K. K. Guha Roy, B.A., with additions by P. C. Mahalanobis, M.A., I.E.S. (Miscellaneous Bulletin No. 9 of the Imperial Council of Agricultural Research, Delhi), 1936. Pp. 120. Price Rs. 2–2 or 4*s*.

Agricultural research workers engaged in problems involving the aid of modern developments in statistical theory will welcome this bibliography. It consists of two parts. The first gives a list of statistical books including some important tables as those of Karl Pearson's. In the second part are three sections. The first section gives references to papers dealing with mathematical theory, namely, averages and variance, correlations, frequency curves, goodness of fit, etc. The second part gives references to papers where their principles are applied as in field trials, meteorological research, genetics and other fields of research. The third section is an addendum.

The authors confess that exhaustiveness was not their chief aim. Here is a record of some references found in some journals in the Pusa library with additions made from the Statistical Laboratory at Calcutta. The purpose of a bibliography is two-fold. It enables research workers to avoid a repetition of work already completed elsewhere, and at the same time provides help to those seeking light on some definite problems. Therefore one would consider exhaustiveness the chief merit of any bibliography. It is hoped that this preliminary edition will be quickly followed up by an exhaustive bibliography.

D. S. R.

Biréfringence Magnétique de l'Oxygène liquide, de l'Azote liquide et de leurs Mélanges. Par P. Lainé. (No. 324 of the Actualités scientifiques et industrielles.) (Hermann et Cie, Paris), 1936. Pp. 55. Price 15 *fr.*

This is an account of the experiments made by the author on the magnetic birefringence of liquid oxygen and liquid nitrogen and their mixtures, using the large Bellevue electromagnet. The experimental arrangement is briefly described. The result found is that the variation of the magnetic birefringence of liquid oxygen varies as $1/T^2$ as required by Langevin's theory (T is the absolute temperature). But the magnitude of the Cotton-Mouton constant comes out too small and since the Leyden investigators have found that the variation of the susceptibility does not follow the 1/T law predicted by Langevin's theory, the author proposes a new explanation. The theories of G. N. Lewis and of Rocard and Goldstein to account for the Leyden results are criticised and a new hypothesis is advanced based on the assumption of the validity of Boltzmann's law of distribution and of the existence of oxygen in three different states with the spins -1, 0 and $+1$ and also the presence of the polymer O_4 in different concentrations at different temperatures. Further experiments to test this hypothesis are suggested. The results are interesting and of importance, but since a fuller account is promised in the *Annales de Physique*, the present mode of publication seems to be a departure from ordinary practice.

Le Deutérium ou Hydrogène lourd. Deuxième Partie. Par E. Darmois. (No. 344 of the Actualités scientifiques et industrielles.) (Hermann et Cie, Paris), 1936. Pp. 40. Price 10 *fr.*

This is a resumé of the new results that have been obtained since the first part was published in the same series. The physical and chemical properties of deuterium and of its compounds are discussed in relation to those of hydrogen and its compounds. In spite of the catalogue-like nature of the subject the presentation is lively and interesting. But there are some errors which should be eliminated from a book of reference such as this brochure is intended to be. Thus in the table on p. 12 the latent heat of fusion of DCl is given as 141 cals./Mol and that of HCl as 476 whereas 476 is the value for DCl and that of HCl is 498·2. The magnetic moment of the deuton is said to be 1/5 that of the proton while Kalckar and Teller and Farkas and Farkas have shown the ratio to be $\frac{1}{4}$. On p. 15 we find, v_1, v_2, v_3 for ν_1, ν_2, ν_3. On the same page the symbol Be for the band constant usually designated B_e may cause confusion with the symbol for Beryllium. The elimination of these and a few other typographical errors will increase the usefulness of the pamphlet.

Chaleur Spécifique et Théorïe des Quanta. Par Prof. Chr. Musceleanu. In two parts. (Nos. 321 and 322 of the Actualités scientifiques et industrielles.) (Hermann et Cie, Paris), 1936. Première Partie—Pp. 49, Price 15 *fr.* Deuxième Partie,—Pp. 35, Price 12 *fr.*

The two monographs give a resumé of the theory of specific heats, commencing with Thermodynamics, and Kinetic Theory and the Equipartition theorem, and going on to the quantum theories of Einstein, Nernst and Lindemann, and Debye. The elements of Statistical Mechanics are introduced to deduce Planck's expression for the energy of an oscillator. The ground covered is that usually found in text-books but the addition of a few pages on Born and Karmán's theory of the specific heat of crystals is an important asset for the book. The presentation is good but occasionally roundabout methods are employed. We are pained to find misprints on every page without exception. If these are removed, the books will provide profitable reading.

Les Théories Quantiques. Par René Arditti. (No. 330 of the Actualités scientifiques et industrielles.) (Hermann et Cie, Paris), 1936. Pp. 33. Price 8 *fr.*

This is the substance of a lecture delivered at the Conservatoire national des Arts et Métiers on the quantum theory of valency. Bohr's theory of the atom and Pauli's principle in its application to the Periodic Table occupy about half the book and then the wave equation is introduced and the idea of quantum mechanical resonance is explained. The theory of valency is then briefly and qualitatively expounded. This would serve as a useful introduction but for the numerous mistakes in the book. Thus Bohr's frequency condition is stated to be $\nu = \frac{E_p - E_q}{nh}$ with n an integer. On the same page the quantification of the minor axis of the elliptic orbit is said to result from relativistic considerations, while the precession of the major axis is ascribed to the movement of the electron and proton round their centre of gravity as contrasted with the motion of the electron round the nucleus. The spin s is said to have the values $\frac{1}{2}$ and $-\frac{1}{2}$ and m stands for m_l. In the Schrödinger equation on page 17, the factor m is missing. The dissociation energy D is given in volts per cm. We find Polaniy for Polanyi and van t' Hoff for van't Hoff. On the whole the volume does little credit to the series in which it appears.

Activité et Interaction Ionique. I.—Expose Theorique. II.—Experimentale de l'Activite des sels de Metaux lourds. By M. Quentin. (Actualités Scientifiques et Industrielles.) (Hermann and Cie, Paris), 1935, No. 309—Pp. 33, Price 8 *fr.* No. 310—Pp. 90, Price 18 *fr.*

The first monograph gives a clear exposition of Debye and Huckel's theory of strong electrolytes, the approximations used in the same, and the subsequent developments of the theory by Bjerrum and by Gronwall and La Mer to take account of the deviations between theory and experiment. The second number gives an account in detail of the author's experiments on the activity of the salts of heavy metals which can be regarded as intermediate between strong and weak electrolytes. In calculating the mean activity of a salt the majority of workers assume for the sake of simplicity that the radius

'a', the parameter in Debye's theory, is the same for each ion. This assumption has no basis, and indeed the author finds that for $CdCl_2$, the values are different for the cadmium and the chlorine ions. The values of the mean coefficient of activity at different concentrations show that the relative departure from Debye-Huckel's theory passes through a maximum at what are usually considered as very dilute solutions: thus, for $CuSO_4$, it is 40% at 0·001 M, and 6% at 0·1 M. The results are further discussed in relation to the formula of Cromwell and Lamer and of Bjerrum, and the existence of incomplete dissociation.

The two monographs together keep up the usual standard of the Actualite series.

M. A. G.

Mathematics for Technical and Vocational Schools. By Samuel Slade and Louis Margolis. (John Wiley & Sons, Inc., New York; Chapman and Hall, Ltd., London), 1936. Second Edition. Pp. 517. Price 12*s*. 6*d*.

All progressive countries in the world, in which a constructive system of education is in vogue, have of late developed their own systems of vocational and technical training. With the rapid growth of trade and industry, the need for imparting technical education in suitably equipped schools has been increasingly felt, as a result of which, the number of such schools is increasing every year. It has been rightly felt that no knowledge of modern industry is sound, without a clear understanding of the mathematical and scientific principles, on which the essential parts of the various machinery employed in the factory and the mechanical shop are based and constructed; at the same time it is important to see that the student in the vocational school is not burdened with unnecessary and elaborate details of mathematics or theoretical science. Such portions of mathematics as are useful to the student of vocational education, will have to be sifted out and properly knit together in logical sequence in a clear and understandable manner. Judged from this point of view, the authors have achieved a large measure of success.

The aim of the authors has been to "produce a practical working text-book on mathematics as applied to technical and trade work, the aim being to teach the pupil how to solve the problems that occur in his work." Theoretical discussion and derivation of formulas, etc., have been minimised. The portions dealt with include useful matter from Arithmetic, Algebra, Geometry, Trigonometry, Dynamics and Statics. A large number of examples of every-day interest and use have been given. The explanations are clear and lucid and adequately illustrated. The treatment is designed to meet the needs of the pupil dealing with machine-shop problems; this is clearly understood, when it is mentioned that the twenty-four chapters comprising the book deal with such topics as mensuration, practical computation, slide rule, strength of materials, windmills, speed ratio of pulleys and gears, screw threads, etc. There is no doubt that the book will serve a very useful purpose. The large number of useful tables given at the end of the book will serve to enhance the usefulness of the book. We unhesitatingly recommend it as a text-book for use in the technical high schools that are rapidly springing up in this country.

La masse en cinématique et théorie des tenseurs du second ordre. By Ch. Platrier. (Actualités scientifiques et Industrielles, No. 326.) (Hermann et Cie, Paris), 1936. Pp. 81. Price 18 *fr*.

This volume is the second of a series of three books written by the author on the science of kinematics which is one of the important branches of the mechanics of rigid, and deformable bodies. The subject-matter is the substance of lectures delivered by the author to the students of the Technical College of France. The third chapter of the book is very instructive and it is well written and gives an account of the elementary notions of the tensors of second order. The fourth chapter deals with the moments and products of inertia and the remaining five chapters are mainly devoted to theorems of Koenig on the laws of kinematics and to some of their important applications. The book may be considered to be a good introductory volume to the study of more advanced vectorial mechanics. As far as possible the classical method has been avoided and vectors and tensors are used freely throughout the book. Though the subject-matter is elementary, the treatment is modern and the exposition is quite lucid and illuminating.

M. N. N.

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THE IMPACT OF SCIENCE UPON SOCIETY.

By Sir Josiah Stamp, G.C.B., G.B.E., LL.D., Sc.D., D.Sc., F.B.A.

DURING the past year we have had to mourn the loss of our Patron, King George V, but to rejoice in the honour done us by His Majesty King Edward VIII, himself our most illustrious past President, in taking that office.

Since the beginning of this century the British Association has, till now, added only one new place of meeting in this country to its list. Blackpool can certainly do for science in the North all that Bournemouth achieved in the South: give our record new vigour and itself a new friend.

The reactions of society to science have haunted our presidential addresses with various misgivings for some years past. In his great centenary address General Smuts, answering the question 'What sort of a world picture is science leading to?' declared that one of the great tasks before the human race is to link up science with ethical values and thus to remove grave dangers threatening our future. For rapid scientific advance confronts a stationary ethical development, and science itself must find its most difficult task in closing a gap which threatens disruption of our civilisation, and must become the most effective drive towards ethical values. In the following year a great Engineer spoke as a disillusioned man, who watched the sweeping pageant of discovery and invention in which he used to take unbounded delight, and concluded by deploring the risk of losing that inestimable blessing, the necessity of toil and the joy of craftsmanship, declaring that spiritual betterment was necessary to balance the world. Then came the President of the Royal Society, a supreme Biochemist, on the perils of a leisure made by science for a world unready for it, and the necessity for planning future adjustment in social reconstructions. Followed the Astronomer, deploring man's lack of moral self-control; in knowledge man stands on the shoulders of his predecessor, whereas in moral nature they are on the same ground. The wreck of civilisation is to be avoided by more and not by less science. Lastly, the Geologist gloried in the greatest marvel of millions of centuries of development, the brain of man, with a cost in time and energy that shows us to be far from the end of a mighty purpose, and looking forward confidently to that further advance which alone can justify the design and skill lavished on such a task. So the Geologist pleads then

for scientific attention to man's mind. He has the same faith in the permanence of man's mind through the infinite range of years

> 'Which oft hath swept this toiling race of men
> And all its laboured monuments away,'

that is shown at the Grand Canyon, where, at the point exposing, in one single view, over a billion and a half years of the world's geological history, a tablet is put to the memory of Stephen Tyng Mather, the founder of the National Park Service, bearing what is surely the most astonishing scientific expression of faith ever so inscribed:

> 'There will *never come an end* to the good that he has done.'

We have been pleading then in turn for ethical values, for spiritual betterment, for right leisure, for moral advance, and for mental development, to co-ordinate change in man himself with every degree of advance in natural science in such a harmony that we may at last call it Progress. This extension of our deeper concern beyond our main concern is not really new, but it has taken a new direction. I find that exactly one hundred years ago there was a full discussion of the moral aspects, a protest that physical science was not indeed, as many alleged, taking up so much of the attention of the public as to arrest its study of the mind, of literature and the arts; and a round declaration that by rescuing scientists from the narrowness of mind which is the consequence of limiting themselves to the details of a single science, the Association was rendering 'the prevailing taste of the time more subservient to mental culture'. A study of these early addresses shows that we are more diffident to-day in displaying the emotions and ideals by which I do not doubt we are all still really moved. But they also show that we are pre-occupied to-day with some of the results of scientific discovery of which they were certainly then only dimly conscious. A part of that field, which ought itself to become scientific, is my theme to-day.

What do we mean by impact? My subject is *not* the influence or effect of science upon society—too vast, varied and indeterminate for such an occasion. We may consider the position of the average man, along a line of change we call 'progress,' at the beginning of a certain interval of time and at its end. We might then analyse how much is due to a change in the average man himself, his innate physical and mental powers, and how much to other influences and particularly to science. We may debate whether the distance covered is great or small by some assumed standard, and whether progress has been rapid. We might ask whether the direction has been right, whether he is happier or better—judged again by some accepted standard. But our concern here is with none of these questions. I ask whether the transition has been difficult and distressing, in painful jerks and uprootings, costly, unwilling, or unjust; or whether it has been easy, natural, and undisturbing. Does society make heavy weather of these changes, or does it, as the policeman would say, 'come quietly'? The attitude of mind of our order may be either that change is an interruption of rest and stability, or that rest and stability are a mere pause in a constant process of change. But these alternatives make all the difference to its accommodating mechanisms. In one case there will be well-developed tentacles, grappling irons, anchorages, and all the apparatus of security. In the other, society will put on casters and roller bearings, cushions, and all the aids to painless transition. The *impact* of science will be surprising and painful in the one case, and smooth and undamaging in the other. Whatever may be the verdict of the past, is society and its institutions now learning that change is to be a continuous function, and that meeting it requires the development of a technique of its own?

Science itself has usually no immediate impact upon institutions, constitutions and philosophies of government and social relations. But its *effects* on people's numbers, location and habits soon have; and the resistance and repugnance shown by these institutions and constitutions to the changed needs may rebound or react through those effects upon scientific enterprise itself and make it more precarious or more difficult. Thus the effect of applications of electricity and transport improvements is clearly to make the original areal extent of city or provincial governments quite inappropriate, and the division of functions and methods of administration archaic. If these resist

change unduly they make it more difficult and frictional, and the applications of science less profitable and less readily acceptable. Time makes ancient good uncouth. When two bodies are violent or ungainly in impact, both may be damaged. If the written constitution of the United States, devised for the 'horse and buggy' days, still proves not to be amenable to adjustment for such demands, it will be difficult to overstate the repercussion upon economic developments and the scientific enterprise that originates them. Let the Supreme Court Decision of unconstitutionality on the Tennessee Valley experiment in large scale applied science to natural problems on a co-ordinated plan bear witness. Such unnecessary resistance may be responsible for much of what has been aptly called 'the frustration of science'. Avoidable friction in the reception given to scientific discovery not only deprives the community of advantages it might otherwise have enjoyed much earlier, or creates a heavy balance of cost on their adoption; it may also discourage applied science itself, making it a less attractive and worthwhile pursuit. In that sense we are considering also the impact of society upon science. This too is not new. The Association had as one of its first objects 'to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.' The first address ever offered affirmed that the most effectual method of promoting science was the removal of the obstacles opposing its progress, and the President instanced the very serious obstacles in the science of optics due to the regulations relating to the manufacture of glass. To-day perhaps the scientist places more stress upon the failure of governments to encourage, than upon their tendency to discourage. So much then for the *idea* of impact. Is the scientist or inventor responsible for impact, and if not, who is ?

Elsewhere I have retouched Jeremy Bentham's poignant picture of the inventor of over a century ago, plans and cap in hand, on the doorstep of the rich or influential, waiting for someone to believe in him. From this type of external 'sport' amongst engineers and scientists came much or most industrial innovation, external to the process of business. To-day, in the older and applied sciences affecting industry the solo scientist is the exception and, with the large research departments of particular businesses and trade research associations, the picture is quite different—the expenditure higher, but the results much more rapid and numerous even if for a time they may be kept secret. Although records of finished work may be available over the civilised world, there is much overlapping of current work, but the price of this as a whole is a far smaller fraction of the total result, if we omit from our consideration the first magnitude discoveries of epoch-making influence. The industrial community is now far more amenable than hitherto to scientific influence, indeed it is often the instigator in the mass of minor advances. The new epoch of concerted industrial research dates really from the end of the Great War. During all that time I have held some middle position of responsibility between the research laboratories and institutes on the one hand, and the costing and profit and loss accounts on the other, and my impression is that the proportion of work in which the initiation comes from the business end is steadily increasing. In studies of the periods of scientific and industrial gestation respectively, I have elsewhere defined *scientific gestation* as the time elapsing between the first concept of the idea and its public presentation to society in a form substantially that in which it ultimately finds extensive use without important modification; and *industrial gestation* as the period elapsing from this point to the date when in an economic or industrial sense the innovation is effective. Both periods are difficult to determine exactly in practice, but on a broad view, the period of industrial gestation, with which alone I am here concerned, appears to me certainly to have shortened materially, though possibly at greater social cost. It would obviously be so if industry is actively encouraging research. 'Faraday's discoveries came at the beginning of the great steam era, and for fifty years there would have been no difference in transport even if those discoveries had not been made,' for the telegraph was the only material influence upon it, and practical lighting was delayed till 1900.

In nearly every scientific field there is sub-division of labour, and it is rare that the worker who digs out new truth 'at the face,' so to speak, is also responsible for bringing it to the surface for the public use, still less for distributing the new scientific apparatus or ideas broadly, and even less

for the profitable exploitation of the whole process. These functions are nearly always distinct, even though they are embraced under the one general popular description: chemist, engineer, etc. But in few cases is it any part of the professional training in the subject itself, to study how new products or processes affect the structure or welfare of society. I have questioned many scientific workers and find them, of course, keenly alive to the positive and direct beneficial effects of their work, but they have rarely any quantitative ideas as to negative, indirect and disturbing consequences. All these discoveries, these scientific infants, duly born and left on the doorstep of society, get taken in and variously cared for, but on no known principle, and with no directions from the progenitors. Nor do the economists usually acknowledge any duty to study this phase, to indicate any series of tests of their value to society, or even of methods and regulation of the optimum rate of introduction of novelty. These things just 'happen' generally under the urge of profit, and of consumers' desire, in free competition, regardless of the worthiness of new desire against old, or of the shifts of production and, therefore, employment, with their social consequences. The economist rightly studies these when they happen, but he is not dogmatic about them not being allowed to happen at all in just that way on account of the social disturbance or degradation of non-economic values which they may involve. It is surely a 'no-man's land' for it is rarely that the functions of government begin until a vested problem exists. Especially in Britain we do not anticipate—'Don't worry,—it may never happen.' Problems with us are usually called 'academic' until we are 'going down for the third time'. It is a maxim of political expediency not to look too far ahead, for it is declared that one will always provide for the wrong contingency. The national foresight over wireless was exceptional, and it has to be contrasted with the opportunist treatment of the internal combustion engine. In reply, it can, of course, be urged that no one can foresee just how a scientific idea will develop until it is tried out, rough and tumble, in economic society, and to make anticipatory rules may even hinder its development.

It is rightly stated that the training of the scientist includes no awareness of the social consequences of his work, and the training of the statesman and administrator no preparation for the potentiality of rapid scientific advance and drastic adjustment due to it, no provision of the technical forces which are shaping the society in which he lives. The crucial impact is nobody's business.

When the research worker lifts his attention from his immediate pursuit and contemplates its hinterland, he has three possible areas of thought. He may dwell upon its practical applications and seek to make them as immediate and realistic as possible; moved by the desire not to be merely academic, he may return to his task, to focus his attention primarily on what is likely to be of practical utility, rather than on what is intellectually intriguing. Or he may think of its ultimate social consequences, and speculate on the shifts in demand, the unemployment, the loss of capital, the ultimate raising of the standard of life that may result—in other words, he may engage in economic prevision and social and political planning for the results of his efforts. Or in the third place, he may listen and watch for hints from other fields of scientific study which may react upon his own, and suggest or solve his problems. I do not attempt to give these priority. Economic and political prevision is the most difficult and precarious, because it needs a technique different from his own, and is not given by the light of nature. Specialist scientists have no particular gifts for understanding the institutional processes of social life and the psychology of multiple and mass decisions. It is a tortuous and baffling art to transmute their exact findings into the wills and lives of unscientific millions. But quite a number engage in the pursuit and have not much greater aptitude as amateur ministers of foresight than statesmen would have in planning research. Fewer are skilled, however, in what should be the most appropriate auxiliary to their work—the synthesising of scientific knowledge. The more penetrating they are in their main pursuits, the less may they absorb through analogy or plain intimation from outside. We constantly hear that the average clinical application lags much farther behind the new resources of diagnosis from the laboratory than circumstances compel. But it may be the other way round. The strongest hint of the presence of a particular factor—a positive element in

beri-beri—was given by the clinician to the bio-chemist, who relied entirely on the *absence* of a particular factor, a negative element, no less than fifteen years before the bio-chemist took serious notice, looked for it, and found it. Bacteriology and chemistry await the advance of the bio-chemist before they come effectively to each other's assistance. The cause and prevention of the obstinate degree of maternal mortality are objects pursued *ad hoc*, with hardly a casual glance at the direct appeal of the eugenist to observe the natural consequences of an improvement in female infant mortality two decades earlier.

I do not then pretend to dogmatise as to how far the scientist should become a social reformer. One physicist welcomes the growing sense of social responsibility, among some scientists at least, for the world the labours of their order have so largely created, though he deplores that in this field they are still utterly unscientific. Then another great authority, Sir Henry Dale, declares that it is the scientists' job to develop their science without consideration of the social uses to which their work might be put.

I have long watched the processes by which the scientific specialist 'makes up his mind' in fields of enquiry outside his own. It seems still a matter for investigation whether the development of a specialist's thinking on balance impairs or improves the powers of general thinking compared with what they might otherwise have been. We do not know the kind or degree of truth that may rest in Anatole France's aphorism: 'The worst of science is, it stops you thinking.' Perhaps this was more subtly expressed in the simpler words of the darkie mother: 'If you haven't an education, you 've jest *got* to use yoh brains.'

My own experience is that when the attempt to deal with social consequences is made, we quickly find ourselves either in the field of larger politics debating the merits of the three prevalent forms of state government, or else performing miracles with fancy currencies and their blue prints reminiscent of the chemical engineer.

But there are some essential features of the impact which must be dealt with under any form of society and government and with any machinery for regulating values. They involve man's abilities, his affections and his tools, all of which have been brusquely treated in the past, and might be scientifically treated in the future. An industrial civilisation is unthinkable without division and, therefore, specialisation, of labour, and without tools and capital instruments. Then life itself is not much worth living without social ties and the allegiances of place and kin. These three indispensable elements of the good life bring out defensive mechanisms for their protection. No one likes to see a man highly trained for a special service or specially fitted by natural aptitudes cut off from opportunity to use his powers and reduced to the level of an unskilled biped. No one likes to see the results of abstinence and specially directed labour which is embodied in a great machine or factory rendered impotent long before it has given its life's usefulness. Waste of skill and of capital are alike grave faults by which we should judge and condemn an industrial organisation. And since man does not live by bread alone, if a ruthless industrial organisation continually tears up the family from its roots, transferring it without choice, to new surroundings, destroying the ties of kin, home and social life, of educational and recreational environments, it is far from ideal. Human labour can never be indefinitely fluid and transferable in a society that has a soul above consumption of mere commodities. These three obstructions to change are not final and rigid limitations upon it. Men die, their skill and home associations with them. Plant and equipment wear out. Their successor presents a natural opportunity in each of the three cases for the introduction of change in position, in aptitude, in purpose or design, without waste or human distress. The length of working life and the durability of materials mark the natural phase or periodicity of a smoothly changing society—its quanta, so to speak. But the impetus for change or the irritant has no such intervals. It proceeds from various causes: varying harvests, changes in natural forces; changing human desires and fashions; differences in the rate of growth of population in its different parts; the collective psychological errors of optimism and pessimism in business in an individualistic society; variations in gold supplies and credit policies based thereon. All or any of these, without

invoking any disturbances from the impact of scientific discovery, would serve to make adjustments necessary outside the natural phases to which I have referred, in a society with parts that are interdependent through division of labour, and localisation of industry, joined by foreign trade and convenient transport. These alone would bring about a changing world with incomplete adaptations, loss of capital, and so-called frictional unemployment. It is easy to exaggerate the adjustment necessary for the addition of invention and science to these causes of change. But with the intensification of scientific effort, and the greater subdivision of industry, the possible dislocation becomes more frequent and the ways of meeting such change of greater public importance. This field of inquiry includes widely diverse questions, *e.g.*, patent laws, invention clearing, obsolescence accountancy and costing regulation, taxation adjustments, local rating pooling, trade union regulations, price controls, technical education, age and other discriminations in unemployment relief, transfer bonuses, pension rights, housing facilities, and more selective direction of financial support of intensive scientific research. In this neutral field the specialist scientist and the politician are both amateurs. It is to be covered by each extending his studies, and by specialists who treat impact and change as an area of scientific study.

I do not propose to go over all the ground, so old, so constantly renewed, as to the effect of machinery upon employment. It is known as an historical induction that in the long run, it makes more employment than it destroys, in providing work in making the machinery, in reducing price so that far greater quantities of the commodity concerned may be consumed, and in enabling purchasing power to be diverted to increase other productions. It has even facilitated the creation of a larger population, which in turn has provided the new markets to work off the additional potentiality of the machinery. It does all this in 'the long run,' but man has to live in the short run, and at any given moment there may be such an aggregation of unadjusted 'short runs' as to amount to a real social hardship. Moreover, it comes in this generation to a people made self-conscious by statistical data repeated widespread at frequent intervals, and to a people socially much more sensitive to all individual hardship and vicissitude which is brought about by communal advance.

There are two important aspects of the change induced by science which are insufficiently realised, and which makes a profound difference to the direction of thought and inquiry. The first I will call the 'balance of innovation' and the second the 'safety valve' of population.

The changes brought by science in economic life may be broadly classified as the 'work creators' and the 'work savers'. The latter save time, work and money by enabling the existing supply of particular commodities to be produced more easily, and therefore at lower cost, and finally at lower prices. People can spend as much money as before upon them and get larger quantities or they can continue to buy their existing requirements at a lower cost. In this second event they 'save money' and their purchasing power is released for other purposes. By a parallel process, producing or labouring power is released through unemployment. The released working force and released purchasing power can come together again in an *increased* demand for other products which, to this extent, have not been hitherto within effective demand. The supply of this increase may go part or all of the way to absorb the displaced labour. But this process takes time, and the labour displaced is not at once of the right kind nor in the right place. More important, however, is the invention of quite new objects of public demand, which may be desired in addition to the supply of old ones. This brings together released labour and released purchasing power in the most decisive way. The most orderly and least disturbing phases of progress will be found when these two types of innovation are reasonably balanced. Of course, few new objects of purchasing ambition are entirely additive; most of them displace some other existing supplies. Artificial silk displaces some cotton consumption, radio may displace some types of musical instruments. Recently the German production of pianos and guitars has been at a very low percentage of capacity, and part of this has been made good by the demand for radio sets. The dislocations caused by labour-saving machinery can most easily be made

good by a due *balance* of new labour creating commodities.

A natural increase of population is the best shock absorber that the community can possess, especially if accompanied by an extension of territory such as the United States enjoyed in the constant westward movement of the frontier in the nineteenth century, or Britain in the period of overseas emigration. A moment's reflection will show why this is the case. Assume that 1,000,000 units of a commodity are made by 100,000 men, and that there is an increase of population of 2 per cent. per annum, so that in five years 1,100,000 units will be consumed and employ 110,000 men. Now assume the introduction of a new invention which enables 1,100,000 units to be made by 100,000 men. There will be no displacement of existing labour, but only a redirection of new and potential labour from that industry to other fields. Again, a considerable reduction in demand *per head* can be sustained without dislocation, if the actual aggregate of production demanded is maintained by increasing numbers. The affected industry can remain static and need not become derelict. New entrants to industry will be directed to those points where purchasing power, released through labour-saving devices, is creating new opportunity with new products. New capital is also naturally directed into the new channels, instead of into additions to the old industry.

Now the problem before all western industrial countries is the fact that their populations are shortly becoming stationary (and then will begin to decline noticeably) and this safety valve of increasing population will no longer be available. Every transfer of *per capita* purchasing power to new directions must then be a definite deduction from the old directions, no longer made good by the steady increase in the numbers demanding less per head from those old sources. The impact of science upon a stationary population is likely, *ceteris paribus*, to be much more severely felt than upon a growing population, because the changes of direction cannot be absorbed by the newly directed workers. Of course, the effects of a static population can be mitigated if the *per capita* income is increasing, because a new direction of demand can be satisfied out of the additional purchasing power without disturbing the original directions of demand provided by the original purchasing power. But the change from a growing to a static or declining population is only one type of difficulty. While the aggregate is altering but slowly, the parts may be changing rapidly. Thus, in this country 40·4 millions in 1937 becomes 40·6 in 1942, 40 in 1947, 39·8 millions in 1952, 38·9 in 1957 and 37·5 in 1962. But the children aged 16—which I take because of its influence on schools, teaching and industrial entry—have been estimated, taking those in 1937 as 100, to be 85 in 1942, 73 in 1952 and 62 in 1962. A fall of this magnitude means that industries and institutions dependent upon the present numbers must not be merely static but actually regressive. On the other hand, the old people from 65 to 74 will increase in this ratio—100, 113, 127 and 133. These problems of static populations at home are accentuated by the possibility of a similar tendency abroad, and need thought in advance. The Australian farmer is more affected by the British conditions of population than by his own.

We have thus the first difficulty, that of a static total demand, the second, that the safety valve of new industrial entrants is becoming smaller, but a third difficulty comes from the present tendency of that class. A stationary elderly population must be very inflexible to change, but a stream of new young life, even if it is to be smaller, would give the opportunity for just that change of direction, in training and mobility, which society needs. But unfortunately, in practice this does not now seem to be very adaptable. For we learn from certain Unemployment Insurance areas that while the older people will willingly take jobs at wages a few shillings in excess of the unemployment relief, the younger men are more difficult. For every one that will accept training under good conditions to suit them for eligible work, ten may refuse, and the number who will not go any distance to take work at good wages is also in excess of those who do. Attachment to place for older people is understandable, and has been accentuated by housing difficulties—one learns of miners unemployed in a village where the prospects of the pit reopening are negligible, while at the same time, only twenty miles away new miners are being created by attraction from agriculture to more extended workings in their area. The very social machinery which is set up to facilitate change or to

soften dislocation, aggravates the evil. The first two difficulties are unalterable. This third difficulty is a subject for scientific examination.

So much for the effect of change of any kind upon employment. Now let us narrow this to scientific changes. At any given moment the impact of science is always causing some unemployment, but at the same time the constructive additional employment following upon past expired impacts is being enjoyed. But it is easy to exaggerate the amount of the balance of net technological unemployment. For industrial disequilibrium arises in many ways, having nothing whatever to do with science. Changes of fashion, exhaustion of resources, differential growth in population, changing customs and tariffs, the psychological booms and depressions of trade through monetary and other causes, all disturb equilibrium, and therefore, contract and expand employment in particular places. Our analytical knowledge of unemployment is bringing home the fact that, like capital accumulation, it is the result of many forces. A recent official report indicated that a quite unexpected amount or percentage of unemployment would be present even in boom times. We know already that there may be a shortage of required labour in a district where there is an 8 or 10 per cent. figure of unemployment. So, in this country there may well be a million unemployed in what we should call good times—it is part of the price we pay for the high standard of life secured by those who retain employment. For a level of real wage may be high enough to prevent every one being employable at that wage—though that is by no means the whole economic story of unemployment. Of this number probably 200,000 would be practically unemployable on any ordinary basis—the 'hard core' as it is called. Perhaps seven or eight hundred thousand from the perpetual body, changing incessantly as to its unit composition, and consisting of workers undergoing transition from job to job, from place to place, from industry to industry, with seasonal occupations—the elements of 'frictional' unemployment through different causes. Out of this number, I should hazard that not more than 250,000 would be unemployed through the particular disturbing element of net scientific innovation. This is the maximum charge that should be laid at the door of science, except in special times, such as after a war, when the ordinary application of new scientific ideas day by day has been delayed, and all the postponed changes tend to come with a rush. At any given moment, of course, the technological unemployment that could be computed from the potentiality of new processes over displaced ones, appears to be much greater. But such figures are *gross*, and from them must be deducted all recent employment in producing new things or larger production of old things, due to science. If we are presenting science with part of the responsible account of frictional unemployment at any moment, it will be the total technological reduction due to new processes and displacement due to altered directions of demand, less the total new employment created by new objects of demand. This has to be remembered when we are being frightened by the new machine that does with one man what formerly engaged ten. Perhaps birth-control for people demands ultimately birth-control for their impedimenta.

The rate of introduction of new methods and the consequent impact upon employment may depend upon the size and character of the business unit. If all the producing plants for a particular market are under one control, or under a co-ordinated arrangement, the rate of introduction of a new labour-saving device will be governed by a simple consideration. It can be introduced with each renewal programme for each replacement of an obsolete unit, and therefore without waste of capital through premature obsolescence. But this applies only to small advantages. If the advantages are large, the difference in working costs for a given production between the old and the new types may be so considerable that it will meet not only all charges for the new capital but also amortize the wasted life of the assets displaced before they are worn out. In neither case then is there any waste of capital, and the absorption of the new idea is orderly in time. But it is quite otherwise if the units are in different ownerships. Excess capacity can quickly result from new ideas. A new ship or hotel or vehicle with the latest attractions of scientific invention, quite marginal in their character, may obtain the bulk of the custom, and render half empty and, therefore, half obsolete, a unit built only a year before. The old unit has to compete by lower prices, and make smaller profits. The newer unit is called upon to bear no

burdens in aid of the reduced capital values of the old. It may be that the enhanced profits of the one added to the reduced profits of the other make an average return upon capital not far different from the average that would result in a community where orderly introduction on a renewal basis is the rule. Or perhaps the community gets some of its novelties rather earlier under competitive conditions and pays a higher rate of interest for them as a net cover for the risks of obsolescence. Waste of capital would be at a minimum if the 'physical' life before wearing out were as short as the 'social' life of the machine. To make a thing so well that it will last 'for ever' is nothing to boast about if it will be out of fashion in a few years.

Scientists often look at the problem of practical application as if getting it as rapidly as possible were the only factor to be considered in social advantage, and this difference in the position of monopoly or single management in their ability to 'hold up' new ideas is treated as a frustration in itself. Thus it has been said 'the danger of obsolescence is a great preventative of fundamental applications to science. Large firms tend to be excessively rigid in the structures of production.' Supposing that the obsolescence in question is a real factor of cost, it would fall to be reckoned with in the computation for transition, whatever the form of society, and even if the personal 'profit' incentive were inoperative. It cannot be spirited away. A customary or compulsory loading of costs for short life obsolescence would retard uneconomically rapid competition of novelties and could be scientifically explored.

Now let us look at displaced labour and the costs of it. If the effect of diversion of demand through invention is to reduce the scope or output of particular industries or concerns in private management, they have no option but to reduce staff. If the pressure is not too great, or the change too rapid, this does not necessarily result in dismissals, for the contraction of numbers may be made by not filling up, with young people, the vacancies caused by natural wastage, through death and retirement. But where dismissals are inevitable, re-engagements may take place quickly in the competing industries, otherwise unemployment ensues. Any resulting burden does not fall upon the contracting and unprofitable industry—it has troubles enough of its own already. Nor is it put upon the new and rising industry, which is attracting to itself the transferred profits. In the abstract, it might be deemed proper that before the net gains of such an industry are computed or enjoyed it should bear the burdens of the social dislocation it causes by its intrusion into society. In practice, it would be difficult to assess its liability under this head, and in fact even if it could be determined, new industries have so many pioneer efforts and losses, so many failures, so many superseded beginnings, that it might well be bad social policy to put this burden upon them, for they would be dicouraged from starting at all, if they had to face the prospect of such an overhead cost whatever their results. It would, of course, be theoretically possible to put a special levy on those new industries that turned out to be profitable, and to use it to relieve the social charges of dislocation of labour. But much the same argument could be used for the relief of obsoletism of capital. The distinction would, however, be that in the case of the capital it could be urged that the investor should have been wide enough awake to see the possibilities of the rival, whereas the worker, induced to take up employment in such a superseded industry, was a victim, and could not be expected to avoid it by prevision. In any case, the prevailing sentiment is rather to encourage developing industries, than to put special burdens upon them, in order that the fruits of science may be effectively enjoyed by society with as little delay as possible.

In the upshot, therefore, the injuries to labour, though not to capital, are regarded as equitably a charge to be borne by society in general through taxation, and to be put upon neither the causing nor the suffering business unit.

And it may well be assumed that taken throughout, the gains of society as a whole from the rapid advance are ample enough to cover a charge for consequential damages. But society is not consciously doing anything to regulate the rate of change to an optimum point in the net balance between gain and damage.

The willingness of society to accept this burden is probably mainly due to the

difficulty of fairly placing it, for we find that when it *can* actually be isolated and the community happens fortuitously to have a control, or the workers a power to induce, it will be thrown, not upon the attacking industry, if I may so call it, but upon the defender. Thus in the United States recently, the price of consent to co-ordinating schemes made for the railroads to reduce operating expenses, has been an agreement on this very point. If staff is dismissed, as it was on a large scale in the depression, because of fewer operations and less stock in consequence of reduced carriage through the smaller volume of trade, or through road and sea competition, no attempt is made to put any of the social cost upon the railroads, and the dismissed staff become part of the general unemployed. But if the self-defence of the companies against competition takes the form of co-operation with each other to reduce operations and stock and, therefore, costs, any resultant dismissals are made a first charge upon them. The agreement is elaborate, and has the effect of preventing any adjustments which an ordinary business might readily make when it throws the burden on society, unless those adjustments yield a margin of advantage large enough to pay for their particular special effects. Thus the rapidity of adjustment to new conditions, not to meet the case of higher profits to be made at the expense of workers, but rather to obviate losses through new competition, is materially affected, and a brake is put upon the mechanism of equilibrium in this industry which does not exist in its rivals, or in any others where the power exists to throw it upon the community. A similar provision exists in the Argentine, and it is imposed by Act of Parliament in Canada, but as one of the concerns is nationally owned, and the current losses fall upon the national budget, its charge is really socially borne in the end. In this country such provisions were part of the amalgamation project of 1923, and of the formation of a single transport authority in London in 1933 and, therefore, did not arise through steps taken to meet new factors of competition. But the opportunity for their imposition came when rights to road powers and rights to pooling arrangements were sought by the railways —both of them adjusting mechanisms to minimise the losses due to the impact of new invention—and this was clearly a specialised case of keeping the burdens off the society. In the case of the electricity supply amalgamation of 1933, brought about for positive advantages rather than in defence against competition, similar provision was made, and parliamentary powers for transfers to gas and water undertakings, also not defensive against innovation, have been accompanied by this obligation. In the case of such uncontrolled businesses as Imperial Chemicals and Shell Mex, rationalising to secure greater profits, rather than fighting rearguard actions to prevent losses, obligations to deal with redundancies had been voluntarily assumed. In such cases the public obloquy of big business operations inimical to society can be a negative inducement, but some freedom from radical competition in prices provide a positive power to assume the burden initially, and pass it forward through price to consumers, rather than back against shareholders. The third case, however, of making it a net charge on the improved profits, is quite an adequate outlet. If the principle of putting this particular obstacle in the way of adjustments to meet new competition (as distinct from increasing profits) is socially and ethically correct, it is doubtful whether it is wisely confined to cases where there is quite fortuitously a strategic control by public will.

It will be clear that the difference between the introduction by purely competitive elements involving premature obsolescence and unemployment, and by delayed action, is a cost to society for a greater promptness of accessibility to novelty. The two elements of capital and labour put out of action, would have supplied society with an extra quantity of existing classes of goods, but society prefers to forego that for the privilege of an earlier anticipation of new things. I estimate this price to be of the order of three per cent. of the annual national income. But when we speak of social advantage on balance, outweighing social cost, we dare not be so simple in practice. If the aggregate individual advantage of adopting some novelty is $100x$ and the social cost in sustaining the consequential unemployed is $90x$, it does not follow that it is a justifiable bargain for society. The money cost is based on an economic minimum for important reasons of social repercussions. But the moral effects of unemployment upon the character and happiness of the individual

escape this equation altogether, and are so great that we must pause upon the figures. What shall it profit a civilisation if it gain the whole world of innovation and its victims lose their souls?

So far I have treated the problem of innovation as one of uneconomic rapidity. But there is another side—that of improvident tardiness. Enormous potentialities are seen by scientists waiting for adoption for human benefit, under a form of society quicker to realise their advantage, readier to raise the capital required, readier to pay any price for dislocation and to adjust the framework of society accordingly. A formidable list of these potentialities can be prepared and there is little doubt that with a mentality adjusted for change, society could advance much more rapidly. But there is a real distinction between the methods of adopting whatever it is decided to adopt, and the larger question of a more thoroughgoing adoption. In proportion as we can improve the impact of the present amount of innovation, we can face the problem of a larger amount or faster rate. Unless most scientific discoveries happen to come within the scope of the profit motive, and it is worth some one's while to supply them to the community, or unless the community can be made sufficiently scientifically minded to include this particular demand among their general commercial demands, or in substitution for others, nothing happens—the potential never becomes actual. It has been computed that a benevolent dictator could at a relatively small expense, by applying our modern knowledge of diet, add some two inches to the average stature and seven or eight pounds to the average weight of the general population, besides enormously increasing their resistance to disease. But dictators have disadvantages and most people prefer to govern their own lives indifferently, rather than to be ideal mammals under orders. To raise their own standard of scientific appreciation of facts is the better course, if it is not utopian. It has been clear for long enough that a diversion of part of the average family budget expenditure from alcohol to milk would be of great advantage. But it has not happened. If the individual realised the fact, it certainly might happen. It is ironically remarked that the giving of free milk to necessitous children, with all the net social gain that it may bring about, has not been a considered social action for its own sake, but only the by-product emergency of commercial pressure —not done at the instance of the Ministry of Health or the Board of Education, but to please the Milk Marketing Board by reducing the surplus stocks of milk in the interests of the producer!

Scientists see very clearly how, if politicians were more intelligent, if business men were more disinterested and had more social responsibility, if governments were more fearless, far-sighted, and flexible, our knowledge could be more fully and quickly used to the great advantage of the standard of life and health—the long lag could be avoided, and we should work for social ends. It means, says Mr. Julian Huxley, 'the replacement of the present socially irresponsible financial control by socially responsible planning bodies.' Also, it obviously involves very considerable alterations in the structure and objectives of society, and in the occupations and pre-occupations of its individuals. Now a careful study of the literature of planning shows that it deals mainly with planning the known, and hardly at all with planning for changes in the known. Although it contemplates 'planned' research, it does not generally provide for introducing the results of new research into the plan, and for dealing with the actual *impact*—the unemployment, redirection of skill, and location, and the breaking of sentimental ties that distinguish men from robots. It seems to have not many more expedients for this human problem than our quasi-individualist society with its alleged irresponsibility. It also tends to assume that we can tell in advance what will succeed in public demand and what will be superseded. There is nothing more difficult, and the attempt to judge correctly under the intellectual stimulus of high profits and risk of great losses is at least as likely to succeed as the less personally vital decision on a committee. Would a planning committee, for example, planning a new hotel in 1904, have known any better than capitalist prevision that the fifteen bathrooms then considered adequate for social demand, ought really to have been ten times that number if the hotel was not to be considered obsolete thirty years later? Prevision thought of in terms of hindsight is easy, and few scientists have enjoyed the responsibility of making practical decisions as to what the public will want far ahead. They, therefore, tend to think of prevision

in terms of knowledge and appreciation of particular scientific possibilities, whereas it involves unknown demand schedules, the unceasing baffling principle of substitution, the inertia of institutions, the crusts of tradition and the queer incalculability of mass mind. Of course, in a world where people go where they are told, when they are told, do what they are instructed to do, accept the reward they are allotted, consume what is provided for them, and what is manifestly so scientifically 'good for them' these difficulties need not arise. The human problem will then be the 'Impact of Planning'. I am not here examining the economics of planning as such, but only indicating that it does not provide automatically the secret of correct prevision in scientific innovation. When correct prevision is possible a committee can aim at planning with a minimum disturbance and wastage (and has the advantage over individuals acting competitively), but for such innovation as proves to be necessary it does not obviate the human disturbance or radically change its character. The parts of human life are co-ordinated and some are more capable of quick alteration than others, while all are mutually involved. One may consider the analogy of a railway system which has evolved, partly empirically and partly consciously, as a co-ordinated whole. Suddenly the customary speed is radically changed, and then it may be that all the factors are inappropriate—distance between signals, braking power, radius of curves, camber or super-elevation, angles of crossings, bridge stresses. The harmony has been destroyed. Especially may this be the case if the new factor applies to some units only, and not to all, when the potential density of traffic may be actually lessened. The analogy for the social system is obvious and its form of government matters little for the presence of the problem, though it may be important in the handling of it.

I have spoken as though the normal span of life of men and machinery themselves provides a phase to which scientific advance might be adjusted for a completely smooth social advance. But this would be to ignore customs and institutions, even as we see in Federal America, Australia and Canada, constitutions which lengthen that phase and make it less amenable as a natural transition. At one time we relied on these to bring about the economic adjustment necessary. But technical changes take place so rapidly that such forces work far too slowly to make the required adaptation. Habits and customs are too resistant to change in most national societies to bring about radical institutional changes with rapidity, and we patch with new institutions and rules to alleviate the effects rather than remove the causes of maladjustments. The twenty mile speed limit long outstayed its fitness, and old building restrictions remained to hamper progress. Edison is reported to have said that it takes twenty-five years to get an idea into the American mind. The Webbs have given me a model period of nineteen years from the time when an idea comes up as a practical proposition from a 'dangerous' left wing to the date when it is effectively enacted by the moderate or 'safe' progressive party. This period of political gestation may be a function of human psychology or of social structure. We do not know how ideas from a point of entry, permeate, infiltrate or saturate society, following the analogues of conduction, convection, or lines of magnetic force.

Our attitude of mind is still to regard change as the exceptional, and rest as the normal. This comes from centuries of tradition and experience, which have given us a tradition that each generation will substantially live amid the conditions governing the lives of its fathers, and transmit those conditions to the succeeding generation. As Whitehead says: 'we are living in the first period of human history for which this assumption is false.' As the time span of important change was considerably longer than that of a single human life, we enjoyed the illusion of fixed conditions. Now the time span is much shorter, and we must learn to experience change ourselves.

I have so far discussed modification of impact to meet the nature of man. Now we must consider modifying the nature of man to meet impact.

Sociologists refer to our 'cultural lags' when some of the phases of our social life change more quickly than others and thus get out of gear and cause maladjustments. Not sufficient harm is done to strike the imagination when the change is a slow one, and all the contexts of law, ethics, economic relations and educational ideals tend towards harmony and co-ordination. We can even tolerate by our conventions, gaps between

them when preachers and publicists can derive certain amusement and profit from pointing out our inconsistencies. But when things are moving very rapidly, these lags become important; the concepts of theology and ethics, the tradition of the law, all tend to lag seriously behind changes brought about through science, technical affairs and general economic life. Some hold that part of our present derangement is due to the lack of harmony between these different phases—the law and governmental forms constitutionally clearly lag behind even economic developments as impulsed by scientific discovery. An acute American observer has said that 'the causes of the greatest economic evils of to-day are to be found in the recent great multiplication of interferences by Government with the functioning of the markets, under the influence of antiquated doctrines growing out of conditions of far more primitive economic life.' It would be, perhaps, truer to say that we are becoming 'stability conscious' and setting greater store, on humanitarian grounds, by the evil effects of instability.

In the United States it would be difficult to find, except theoretically in the President, any actual person, or instrument in the Constitution, having any responsibility for looking at the picture of the country as a whole, and there is certainly none for making a co-ordinated plan. Indeed, in democracy, it is difficult to conceive it, because the man in public life is under continual pressure of particular groups, and so long as he has his electoral position to consider, he cannot put the general picture of progress in the foreground. Whitehead declared that when an adequate routine, the aim of every social system, is established, intelligence vanishes and the system is maintained by a co-ordination of conditioned reflexes. Specialised training alone is necessary. No one, from President to miner, need understand the system as a whole.

The price of pace is peace. Man must move by stages in which he enjoys for a space a settled idea, and thus there must always be something which is rather delayed in its introduction, and the source of sectional scientific scorn. If every day is 'moving' day, man must live in a constant muddle, and create that very fidget and unrest of mind which is the negation of happiness. Always 'jam to-morrow'—the to-morrow that 'never comes'. If we must have quanta on stages, the question is their optimum length and character, not merely the regulation of industry and innovation to their tempo, but the education of man and society to pulse in the same rhythmic wave-length or its harmonic.

In some ways we are so obsessed with the delight and advantage of discovery of new things that we have no proportionate regard for the problems of arrangement and absorption of the things discovered. We are like a contractor who has too many men bringing materials on to the site, and not enough men to erect the buildings with them. In other words, if a wise central direction were properly allocating research workers to the greatest marginal advantage, it would make some important transfers. There is not too much being devoted to research in physics and chemistry, as modifying industry, but there is too much relatively to the research upon the things they affect, in physiology, psychology, economics, sociology. We have not begun to secure an optimum balance. Additional financial resources should be applied more to the biological and human sciences than to the applied physical sciences, or possibly, if resources are limited, a transfer ought to be made from one to the other.

Apart from the superior tone sometimes adopted by 'pure science' towards its own applications, scientific snobbery extends to poor relations. Many of the hard-boiled experimental scientists in the older and so productive fields, look askance at the newer borderline sciences of genetics, eugenics and human heredity, psychology, education and sociology, the terrain of so much serious work but also the happy hunting ground of 'viewey' cranks and faddists. Here the academic soloist is still essential, and he has no great context of concerted work into which to fit his own. But unless progress is made in these fields which is comparable with the golden ages of discovery in physics and chemistry, we are producing progressively more problems for society than we are solving. A committee of population experts has recently found that the expenditure on the natural sciences is some eight to ten times greater than that on social sciences. There is hardly any money at all available for

their programme of research into the immense and vital problems of population in all its qualitative and quantitative bearings. An attack all along the front from politics and education to genetics and human heredity is long overdue. Leisure itself is an almost unexplored field scientifically. For we cannot depend wholly on a hit and miss process of personal adaptation, great though this may be. There must be optimal lines of change which are scientifically determinable. We have seen in a few years that the human or social temperament has a much wider range of tolerance than we had supposed. We can take several popular examples. The reaction to altered speed is prominent. In the *Creevey Papers*, it is recorded that the Knowsley party accomplished 23 miles per hour on the railway, and recorded it as 'frightful—impossible to divest yourself of the notion of instant death—it gave me a headache which has not left me yet—some damnable thing must come of it. I am glad to have seen this miracle, but quite satisfied with my first achievement being my last.' In the British Association meeting for 1836, an address on Railway Speeds prophesied that some day 50 miles an hour might be possible. Forty years ago, we may remember that a cyclist doing 15 to 18 miles an hour was a 'scorcher' and a public danger Twenty-five years ago, 30 miles an hour in motoring was an almost unhealthy and hardly bearable pace. To-day the fifties and sixties are easily borne, both by passenger and looker on. Aeroplane speeds are differently judged, but at any rate represent an extension of the tolerance. Direct taxation thirty years ago in relation to its effect on individual effort and action seemed to reach a breaking-point and was regarded as psychologically unbearable at levels which to-day are merely amusing. The copious protection of women's dress then would have looked upon to-day's rationality as suicidal lunacy. One hesitates to say, therefore, that resistances to scientific changes will be primarily in the difficulty of mental and physical adjustments. But there can be little doubt that with the right applications of experimental psychology and adjusted education, the mind of man would be still more adaptable. Unfortunately, we do not know whether education as an acquired characteristic is in any degree inheritable, and whether increasing educability of the mass is a mere dream, so that we are committed to a sisyphean task in each generation. Nor do we know whether this aspect is affected by the induced sterility of the age. It may not be a problem of changing the same man in his lifetime, but of making a larger difference between father and son. The latest teachings of geneticists hold out prospects for the future of man which we should like to find within our present grasp, and recent successful experiments with mammals in parthenogenesis and eutelegenesis bear some inscrutable expression which may be either the assurance of new hope for mankind or a devil's grin of decadence.

What is economics doing in this kaleidoscope?

The body of doctrine which was a satisfactory analysis of society twenty-five years ago is no longer adequate, for its basic postulates are being rapidly changed. It confined itself then to the actual world it knew and did not elaborate theoretical systems on different bases which might never exist. It is, therefore, now engaged in profoundly modifying the old structures to meet these new conditions. Formerly it assumed, quite properly, a considerable degree of fluid or competitive adjustment in the response of factors of production to the stimulus or operation of price, which was really a theory of value-equilibrium. Wherever equilibrium was disturbed, the disturbance released forces tending to restore it. To-day many of the factors formerly free are relatively fixed, such as wage levels, prices, market quotas, and when an external impact at some point strikes the organism, instead of the effect being absorbed throughout the system by adjustments of all the parts, it now finds the shock evaded or transmitted by many of them, leaving the effects to be felt most severely at the few remaining points of free movement or accommodation. Unemployment is one of these. The extent to which this fact throws a breaking strain upon those remaining free points is not completely analysed, and the new economics of imperfect competition is not fully written out or absorbed. The delicate mechanism of price adjustment with the so-called law of supply and demand governed the whole movement, but with forcible fixation of certain price elements consequences arise in unexpected and remote quarters. Moreover, the search for a

communally planned system to secure freedom from maladjustments involves a new economics in which the central test of price must be superseded by a statistical mechanism and a calculus of costs which has not yet been satisfactorily worked out for a community retaining *some* freedom of individual action and choice. The old international currency equilibrated world forces and worked its way into internal conditions in order to do so. But the modern attempt to prevent any internal effect of changes in international trade, or to counteract them, and the choice of internal price stability at all costs against variable international economic equations, has set economic science a new structure to build out of old materials. At this moment when elasticity is most wanted, stability leading to rigidity becomes a fetish. The aftermath of war is the impossibility of organising society for peace.

The impact of economic science upon society to-day is intense and confusing, because, addressing itself to the logic of various sets of conditions as the likely or necessary ones according to its exponents, predilections, it speaks with several voices, and the public are bewildered. Unlike their claims upon physics and mathematics, since it is dealing with money, wages, and employment, the things of everyday, they have a natural feeling that it ought to be easily understandable and its truth recognisable. Balfour once said, in reference to Kant, 'Most people prefer a problem which they cannot explain, to an explanation which they cannot understand.' But in the past twenty years, the business world and the public have become economics-conscious, and dabble daily in index numbers of all kinds, and the paraphernalia of foreign exchange and statistics of economic life. The relativity of economic principle to national psychology baffles the economists themselves, for it can be said truly at one and the same time, for example, that confidence will be best secured by balancing the Budget, and by not balancing it, according to public mentality. The economics of a community not economically self-conscious are quite different from those of a people who watch every sign and act accordingly. Thus the common notion that economics should be judged by its ability to forecast (especially to a particular date) is quite fallacious, for the prophecy, if 'true' and believed, must destroy itself, inasmuch as the economic conduct involved in the forecast is different after the forecast from what it would have been before. The paradox is just here, for example: if a people are told that the peak of prices in a commodity will actually be on June 10, they will all so act that they anticipate the date and destroy it. Economics, thoroughly comprehended, can well foretell the effects of a tendency, but hardly ever the precise date or amount of critical events in those effects. The necessity for a concentration upon new theoretical and analytical analysis, and upon realistic research is very great. But so also is the need for widespread and popular teaching. For a single chemist or engineer may by his discovery affect the lives of millions who enter into it but do not understand it, whereas a conception in economic life however brilliant, generally requires the conformity of the understanding and wills of a great number before it can be effective.

But not alone economics: if the impact of science brings certain evils they can only be cured by more science. Ordered knowledge and principles are wanted at every point. Let us glance at three only, in widely different fields: man's work, man's health, man's moral responsibility. The initial impact of new science is in the factory itself. The kind of remedy required here is covered by the work of the National Institute of Industrial Psychology. Some of this improves upon past conditions, some creates the conditions of greater production, but much of it combats the evils arising from new conditions created by modern demands, speed, accuracy and intensity. It invokes the aid of many branches of science. It is the very first point of impact. Yet its finance is left to personal advocacy, and commands not 10 per cent. of the expenditure on research in artificial silk, without which the world was reasonably happy for some centuries. We can judge of the scope of this by the reports of the Industrial Health Research Board. Again, the scientific ancillaries of medicine have made immense strides. Clinical medicine as an art makes tardy, unscientific and halting use of them. The public remain as credulous as ever, their range of gullibility widened with every pseudo-scientific approach. (We do not know what proportion of positive cases can create the illusion of a significant majority in mass psychology, but I suspect that it is

often as low as twenty per cent.) For a considerable range of troubles inadequately represented in hospitals, the real experience passes through the hands of thousands of practitioners, each with too small a sample to be statistically significant, and is, therefore, wasted from a scientific standpoint. Half-verified theroies run riot as medical fashions, to peter out gradually in disillusionment. If the scattered cases were all-centralised through appropriately drawn case-histories, framed by a more scientifically trained profession, individual idiosyncrasy would cancel out, and mass scrutiny would bring the theories to a critical statistical issue of verification or refutation in a few months. This would be to the advantage of all society, and achieve an even greater boon in suggesting new points for central research.

A suggestion has been made for an inventions clearing house, to 'co-operate the scientific, social and industrial phases of Invention, and to reduce the lag between invention and application' managed by a committee of scientists and a committee of industrialists and bankers. The proposal came to me from New York, but London was to be the home of the organisation, which was to adopt a code of ethics in the interests of inventors, industry and *social progress*. This brings me to my third example, the field of ethics, which needs the toil of new thought. The systems of to-day, evolving over two thousand years, are rooted in individualism and the relations between individuals. But the relations of society to-day are not predominantly individual, for it is permeated through and through with corporate relations of every kind. Each of these works over some delegated area of the individual's choice of action, and evolves a separate code for the appropriate relationship. The assumption that ethical questions are decided by processes which engage the individual's whole ethical personality is no longer even remotely true. The joint-stock company may do something, or refrain from doing something, on behalf of its shareholders, which is a limited field of ethics, and may but faintly resemble what they would individually do with all other considerations added to their financial interests. The whole body of ethics needs to be reworked in the light of modern corporate relations, from Church and company, to cadet corps and the League of Nations.

In no case need we glorify change: but true rest may be only ideally controlled motion. The modern poet says:

> 'The endless cycle of idea and action,
> Endless invention, endless experiment,
> Brings knowledge of motion, but not of stillness.'

But so long as we are to have change—and it seems inevitable—let us master it. T. S. Eliot goes on:

> 'Where is the wisdom we have lost in knowledge?
> Where is the knowledge we have lost in information?'

My predecessors have spoken of the shortcomings of the active world—to me they are but the fallings short of science. Wherever we look we discover that if we are to avoid trouble we must take trouble—scientific trouble. The duality which puts science and man's other activity in contrasted categories with disharmony to be resolved, gaps to be bridged, is unreal. We are simply beholding ever-extending science too rough round the edges as it grows.

What we have learnt concerning the proper impact of science upon society in the past century is trifling, compared with what we have yet to discover and apply. We have spent much and long upon the science of matter, and the greater our success the greater must be our failure, unless we turn also at long last to an equal advance in the science of man.

Principles and Practice of Field Experimentation.*

A VERY useful publication by the well-known statistical experts Drs. Wishart and Sanders which will prove very helpful in clearing up many a difficulty with which the agricultural experimenter is confronted has recently appeared. The earlier statistical publications by the same publishers are now out of date, and the present one shows in a nutshell all recent improvements in field technique. Very few agricultural experimenters in India are in a position to understand critically Dr. Fisher's book *Statistical Methods for Research Workers*, though Dr. Fisher's methods of field technique are now being rigidly followed, in every farm in India and his ideas of *randomisation* and *replication*, and the mathematical concept of 'Analysis of Variance' have now become classical in the theory of field experimentation. Technical Communication No. 10 of Imperial Bureau of Soil Science—1930 (*The Arrangement of Field Experiments and the Statistical Reduction of the Results* by Fisher and Wishart) which is very popular now, clarified to a considerable extent most of Fisher's ideas, though the experimenter still felt that there were a few fundamental points on which the authors had not given a clear guidance to him.

Taking Part II first, of the publication under review, it attempts to answer most of the practical questions facing an experimenter. The authors have made however clear even at the outset, that Statistics is only a means to an end and that undue prominence should not be given to it in preference to botanical or chemical techniques which might require his greater attention. This is indeed a very useful warning, as in India too, there seems to be a tendency to exaggerate the usefulness of 'statistics' in field technique at the sacrifice of other important scientific considerations that should govern an experiment. But the part which 'statistics' plays cannot be denied both in the matter of the design of the experiment to answer specific problems, and in eventually reducing the results to a form from which valid conclusions could be deduced. The modern field technique, besides, is a considerable improvement over old methods, in that what are known as 'Complex Experiments' which involve a number of factors at a time such as several varieties and manures, are now becoming very popular.

The conduct of an experiment, if the data should be capable of satisfactory interpretation, involves a number of preliminary considerations which the authors have so lucidly set forth; firstly a suitable site for the experiment is a necessity; which should be *uniform* in surface soil, sub-soil and drainage, and with a history fairly known, which will be a guide for minimising the effects of patches in all possible ways. But such 'a uniform piece of land' is almost impossible, and the statistical device is to carry out a *uniformity trial* in the year or years previous to the experiment, and to correct the yield of a plot in the experimental year on the basis of the preliminary yield (by what is known as 'Covariance' method referred to again in a subsequent para). But unless the covariance or correlation between the preliminary and experimental yields in individual plots is high enough, which will lead to a large reduction of error, the *uniformity trial* loses its significance; and this is what has been found to be the case in experiments on *annual* crops where the correlation was found to be low. But in the case of perennial crops like 'tea', the method of covariance has yielded very valuable results.

The soil type of the farm should, of course, be representative of the country where the results of the experiment have to be applied in wider practice, and the experiment itself should include 'an established variety or method of cultivation' to act as the standard. Since the results of a single experiment are for one year only, it seems necessary before any practical recommendations are made with regard to their wider utility, that the experiment should be continued for at least three years to allow for weather sampling, and at as many centres as possible. Where such series of experiments are statistically combined for analysis (which would allow sufficient degrees of freedom for error), it should be noted that the *size and shape* of experimental plot should be kept constant, though the actual *randomisation* of plots should be done separately for each experiment.

The authors have rightly pointed out that a mere *significant* difference in the matter of yield is not sufficient to introduce

* *Principles and Practice of Field Experimentation.* By J. Wishart, M.A., D.Sc., and H. G. Sanders, M.A., Ph.D. (Empire Cotton Growing Corporation, King's Buildings, Dean Stanley Street, London, S.W. 1.) 1935. Pp. 100. Price 3/-, post free.

a new variety, for on one hand there is the question of economics, as even a 10% increase may not be an economic advantage, and on the other hand there is the question of *quality*. There is however the difficulty of assessing the *quality* of crops, which as in the case of *pasture*, becomes complicated, as it depends both upon nutritive value and botanical composition. With cereals, *ability to stand* is an important consideration, as well as *earliness*. These are some of the points which should weigh with the experimenter before a definite variety is decided upon for extension. It seems therefore necessary from the point of view of deduction of proper results that *experimental plots* should also be accompanied by *observation plots*. The observation plots are generally used at the first stage of the enquiry for trying any number of new varieties, and eliminating as many as possible for the final experiment, but they serve much more useful purpose throughout the different stages of the enquiry, as large plots will be necessary to watch the *standing ability* of plants, their *tillering* capacity and effects of *spacing*, and so on. It is advisable to have such observation plots as close as possible to the experimental field.

Size, Shape and Arrangement of Experimental Plots.

Every experimenter knows that dealing with small plots, their *size*, *shape* and *arrangement* influence the standard error of the experiment. But so far, we in India have not definitely deduced what these should be for several crops grown under different conditions and for different types of experiment. These questions could however be solved only by special experiments designed for the purpose. But the authors have given some very useful tips which are worth noting. The uniformity trials in other countries show generally—these are corroborated by trials in India as well—that standard error goes down as the plot size increases to 1/40 acre, and that error goes up as we still further increase the size. But as a sufficient number of replications is necessary for ensuring validity for error, it is recommended that we may have even smaller plots than 1/40 acre, and increase the number of replications. Larger plots too could sometimes be preferred, if they could improve the convenience of agricultural operations.

With regard to plot-shape, the *square plot* has the advantage of minimising the edge effects (as in the case of cereals, lodging is a serious matter), while *oblong plots* may be helpful to take detailed growth observations by facilitating easy access to any part of the plot. In cultivation experiments it seems imperative to have long narrow plots, so also in the case of all experiments where plots should be separately drilled. Long narrow plots are, generally speaking, found to give lower standard error than square plots; and it is particularly so in slopy areas with long sides of the plot running up the slope.

A further point which is of considerable moment to the experimenter is whether the Latin Square or randomised block arrangement should be preferred. Both the methods have advantages and disadvantages, and the type of experiment to be conducted seems to be the deciding factor in preferring the choice. While the Latin Square has the advantage of eliminating soil fertility in two directions, and is convenient for small dibbled plots, it has the disadvantage that the number of treatments or replications cannot exceed 7 or 8, as it will otherwise cover a large space and reduce the efficiency of the experiment; nor can the treatments be less than 3 or 4 owing to the number of degrees of freedom being very small. One other point—which the authors have not touched—is that in the case of irrigation or manurial experiments the lateral seepage of water is a great disturbing factor, particularly so in the case of a Latin Square arrangement.

But with regard to 'randomised blocks design', its flexibility is its supreme merit; there is no theoretical restriction to the number of treatments (though there should be a limit to the block size and hence to the number of treatments which should not normally exceed 10); and above all the randomised block method can be fitted even to an awkward-shaped field. For cultivation experiments, and drilling trials this method is admirably fitted, and the accessibility to each plot which the arrangement permits is indeed a great advantage. However, how far either method reduces the error has not been fully explored, and here the experimenter in India has ample scope for research.

But where the number of treatments is to be unduly large, what are known as 'confounded experiments' are now being adopted and the authors have not entered into a discussion of these very useful designs, except a reference to what are known as 'split-plot designs', which are now being largely used in India for irrigation and manurial experiments.

Pages 81–85 contain very useful points of advice to the experimenter. The number of replications to be adopted should be based from experience on the *standard error of the mean*; and for detecting *small* differences a larger number of replications will be necessary. Again it is wrong to adopt 'the same randomisation' for several experiments (instead of randomising each time), as it may introduce a bias; it is a mistake again to divide a plot into two or three and imagine that the replications are increased. Further, the process of 'randomisation' itself needs some definite procedure. Tippet's tables are now being largely used for picking random numbers, and if they are not available some convenient method of drawing—such as picking up cards—may be adopted. 'Randomisation' in the case of *Latin Square* is rather a cumbersome procedure, and it seems best to draw one of the types given by Yates (1933, *Empire J. Expt. Agri.*, i). Otherwise for the formation of Latin Square for use in field experiments, the rows may be picked up first with all the limitations of the Latin Square, and then the rows and columns may be randomised, amongst themselves.

SAMPLING TECHNIQUE.

This is probably the greatest difficulty facing the experimenter, and the authors have given a very clear guidance on the matter. 'Sampling of plants' merely means picking up a certain percentage of plants for observation, and such a selection is necessary where the population is very large. Developmental observations from stage to stage in the growth of the plant, such as its height, weight, etc., which would eventually explain the differences in yield, can best be done only by *sampling*; otherwise the process of counting and observation would become unnecessarily complicated. The sampling of plants from each plot should however be made free from *bias* and from different portions of the plot to be fairly representative of the plot. The usual sampling procedure is to divide the plot into sections, and to pick up by randomisation a few small areas (known as sampling units) from each section. With at least two sampling units in each unit, the sampling error is calculated as in the case of a split-plot design.

With p plots, 9 sections in each plot, and r sampling units in each section, the sampling error per unit-length will be based on $p\,9\,(r-1)$ degrees of freedom; the sum of squares of 'between sections' in the several plots is first computed, and the difference between the total sum of squares and the sum computed already, will give the sum of squares for sampling, and this divided by $p\,9\,(r-1)$ gives the sampling error per unit, from which the sampling error per plot can be calculated. The actual method of sampling—that is, the distribution of units over the plot—may be done in a number of ways, and here it is, a lot of useful work is possible to determine the best method of sampling on different crops under different conditions such as irrigated and unirrigated. The test for the efficacy for a particular method of sampling is that the sampling error should be low; where it is possible to compare the plot yields with the sample yields, the difference can be calculated, and for the efficacy of the sample, the correlation between the entire yield and the sample yield taken over all the sampling units should be high enough. Experience has shown that at least 5% of the plot yield should be sampled, and that the units should be scattered sufficiently well over the area. Another important point in connection with sampling is whether to take the *same units* at each observation; where it is possible to do so without damaging the plants as in the case of a bulky crop like sugarcane, the same set of plants may be maintained at each observation. In such a case, the *method of covariance* is particularly useful to correct error from stage to stage, and to correct for inequalities in plant number noted at the earlier counts.

Part I of this publication deals with the fundamental principles governing the modern experimentation in a very lucid way. The definition of 'experimental error', the influence of 'soil heterogeneity' in a field experiment, and what is known as 'significance' have all been explained to bring out their full meaning. The exact connotations of 'randomisation', 'replication' and 'local control' have been well illustrated from the layman's standpoint, and the principle of 'analysis of variance' has been well brought out by examples. The routine calculations leading to 'analysis of variance' have been popularised by easy steps. 'z' test and 't' test are a 'bug-bear' to the average experimenter, and from the examples given, these two tests have been well illustrated; and it has been shown that without 'z' test being satisfied, it is statistically unsound to proceed to further comparisons of treatments. The extension of 'analysis of variance' to complex experiments and to

splitplot designs, is logically one more step and the significance of different errors—*e.g.*, errors A and B—in the case of a split-plot design have been explained ; it seems necessary to point out that the split-plot design cannot be used when all comparisons are wanted with *equal precision*.

The principle of 'covariance' so clearly explained in pages 45–56, is indeed a very powerful tool at the hands of the experimenter to clear many complicated points arising in the interpretation of data involving simultaneous variations. The method is particularly useful in correcting a set of data on the basis of preliminary observations, such as for example, yield of one year on the basis of yield of the previous year or years in the same set of plots ; or again the yield may be corrected on the basis of plant or number. Similar to the usual analysis of variance, the table of analysis of covariance is constructed. It would be possible from such a table to know the correlations of 'within groups' or 'error', from which significant relationship or otherwise between the two sets of observations could be judged. The 'corrected' experimental yields are then worked out, which would form the correct basis for drawing inference. At Cambridge it has now become the habit to work out 'covariance' on all preliminary observations, and calculate r and b ; if these are insignificant a further procedure becomes useless.

Conclusion.

The authors have thus covered practically almost the whole ground useful to the agricultural experimenter (except the principle of 'confounding' which is now being applied in a large measure to factorial designs), and have elucidated many points of interest. But it should be said that research suitable to our own conditions should be carried out to evolve our own standards in the matter of field technique.

M. Vaidyanathan.

Ancient Schistose Formations of Peninsular India*

THE most recent geological map of India appeared in 1931. No description of the geology of the country was published with the map ; Sir Edwin Pascoe is now engaged in compiling such a description and this will appear at an early date as a *Manual of the Geology of India*. Some sixty per cent. of the area of the Peninsula is occupied by crystalline rocks and it is to be expected, perhaps, that these should receive a more detailed treatment than can be incorporated in a manual. It is such a treatment that Sir Lewis now contemplates.

There are two methods of attempting such a comprehensive work. One method is to write the whole and revise it immediately before submitting it to the Press ; unfortunately, if the result is to be satisfactory, revision may mean the complete rewriting of the whole—a case in point is the *Geology of Australia* written by Sir Edgworth David and revised so thoroughly that it had not reached the Press up to the time of Sir Edgworth's lamentable death in 1934. The other method is to publish it piecemeal as the parts are written, with a final appendix in which may be summarised all that new material which accumulated during the successive appearance of the different parts. Presumably Sir Lewis intends to follow the latter plan.

The investigation of metamorphic rocks is a specialist's life study. Sir Lewis is such a specialist and his 17 years of field work included in 33 years of service in India renders him amongst those fitted to undertake such a work. Many geologists would prefer to see each section in a treatise of this nature from the pen of the authority or authorities in each particular area. Sir Lewis's plan of writing the whole himself at least eliminates the possibility of that acrimonious discussion which is so likely to appear from the clashing of the diverse views of authorities.

Those of us who have worked on metamorphic rocks and have also visited areas of metamorphic rocks in other countries will appreciate something of the task which

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* " An attempt at the correlation of the ancient schistose formations of Peninsular India," by Sir Lewis Fermor, *Memoirs of the Geological Survey of India*, **1936, 70,** Part I, 51 pp. With one map.

Note : The memoir, part I of which is the subject of this review, is a comprehensive discussion on the Archæan rocks of India from the pen of Sir Lewis Fermor ; the remaining parts are to appear from time to time during, it is hoped, the next few years.

Sir Lewis has set himself for India. In this country we have had detailed mapping in widely separated areas, and attempts at correlation may be compared, perhaps, to attempts at correlating the rocks of the Lake Superior region with metamorphic rocks in the Alleghanies, the Black Hills and in the Rockies, or between Scotland, Scandinavia and Central Europe. Unfortunately we are too prone to think of a country as a geological entity, forgetting the vastness of a country like India and the great distances separating the mapped areas. Except in a few isolated regions the geological map of India gives but a crude sketch of the Archæan rocks.

Detailed mapping on careful modern lines has been in progress for little more than 20 years; Sir Lewis makes the illuminating remark that "Most of our memoirs on the geology of Southern India were written before the introduction of the microscopic study of rocks into India." However, in Rajputana Dr. Heron's record of nearly 30 years of continuous mapping has resulted in the only satisfactorily completed areal unit in India. In other parts of India most of the work has been in progress continuously since the War. In the Central Provinces Sir Lewis Fermor's party has done some fine detailed mapping over a comparatively small area. In Bihar and the adjacent Eastern States Agency a party, centred around Singhbhum, has covered a rather larger area in detail. Recently a survey party commenced work in Bastar State which should clear up some of the problems of the Charnockites and related rocks. Geological surveys in South India have gone on continuously, but no connected account has appeared in recent years. These facts will indicate the real paucity of connection between these isolated areas.

Sir Lewis recognises all the difficulties and clearly enumerates them. One turns these first pages with something of awe for this brave attempt—there will be much of reverence if, on its conclusion, Sir Lewis has unrolled before us a convincing picture of any detailed correlation which he may make.

Part I is introductory in nature, its principal object being to discuss the several factors which may be concerned in correlation and to divide the country into provinces of a size suitable for description. One may note, at the commencement, that the memoir's title is not perhaps correct seeing that the author intends to describe rocks beyond the Peninsula—in Ceylon, Burma and the Himalayas.

On page 5, Sir Lewis re-quotes his definition of the term Archæan made in 1909; the arguments surrounding the use of the term *eparchæan unconformity* form nothing more nor less than a vicious circle. Cut down to the root of the matter the true definition is found on page 14—"I have taken the presence of either granitic or pegmatitic intrusives as sufficient reason for referring the rocks into which they are intruded to the Archæan rather than the Puranas."

In the excellent discussion of the well-known factors involved in correlation Sir Lewis brings up again the question of crush-conglomerates. I think, from their recent work, several Mysore geologists will demur at the statement: "In the Dharwar series of Mysore there are many conglomerates, but these are all regarded by the Mysore geologists as probably due to crush." Except in Sir Lewis's own area, Central Provinces, this mode of origin for sheared conglomerates seems to have died leaving no regrets.

Apparently the author intends to make some use of the manganese occurrences in correlation. This is dangerous ground of which, no doubt, he is well aware. In the Iron-ore series there is a manganiferous shale horizon near the base and another near the top. Similarly in the use of the iron-ore for the same purpose, although the Iron-ore series is the main source of iron-ores, the pebbles in the basal conglomerate indicate that iron-ores occurred in an older series.

There are several minor points with which some petrologists will not agree, such as metasomatism as an occasional factor in metamorphism, and the solvent action of water in metamorphism, but until we come to the discussion on charnockites there is nothing to cause serious disagreement from the point of view of the purpose of this memoir. Sir Lewis appears to have accepted Stillwell's view that the charnockites are metamorphic rocks of the hypo-zone. Many of us were of this view until recently, but some of us would now revert, in part, to Holland's original description of them as normal igneous rocks. May they not be

rocks formed by the crystallisation of a dry magma at great depth? In discussing, on page 50, why the Cuddapahs never come in contact with the charnockites Sir Lewis gives two reasons. I suggest to him a third: the charnockites were intruded at such great depths that they were nowhere exposed at the surface up to the time of deposition of the Cuddapahs.

For the infra-plutonic zone the author has made a good case and many of us will agree to the probability of his eclogite shell. Its suggested influence in the causation of earthquakes is unconvincing.

Finally, Sir Lewis explains the manner in which he has divided India (unfortunately he heads his table 'Peninsular India') into regions and provinces for purposes of description. The three regions: Non-charnockitic, charnockitic and "extra-Peninsular provinces" give an unbalanced division so far as area is concerned, and especially so when we note that probably 95 per cent. of the work to date has been done in the non-charnockite region. From the metamorphic point of view it is not a petrological division and gives neither a picture of facies nor of grade. It is simply a convenient description of areas, the charnockitic region covering merely the southernmost tip of the Peninsula and the east coast, the non-charnockitic being the rest of the Peninsula.

The eighteen subdivisions, or provinces, are on an areal basis but they are grouped into types some of which are, at least in name, lithological: in the non-charnockitic region there are the iron-ore provinces, the (manganese-ore)-marble provinces and the igneous provinces; in the charnockitic region there are the iron-ore provinces, (manganese-ore)-marble provinces and the garnetiferous provinces; the extra-Peninsular provinces are grouped (naturally) into the Himalayan and Burma occurrences. The grouping contains elements of lithological types, elements of facies and elements of areal distribution—a real hotch potch! Several of the groups contain common characteristics. It might just as well have been left entirely areal. However, classifications of this nature are entirely for clarity in description, and I would not advise the reader to give to it, at this stage, any other significance.

In conclusion I would suggest that as an appendix to the final part of the memoir the authorities on the different areas should be invited by Sir Lewis to express their opinions on his description of their respective areas and of his correlation, and so provide a completely balanced picture.

Correlations are undertaken by two types of people: those who are young and eager (I was rash enough to attempt one such some years ago) and those who, as they retire and leave the field to younger men, wish to leave behind them the fruits of their experience. Sir Lewis Fermor has left India, we wish him a long retirement and hope that he finds the time to put the finishing touches to his correlation.

J. A. DUNN.

A Nutritional Survey of the Poorer Classes in Ceylon.*

Dr. Nicholls gives a brief description of the various races inhabiting Ceylon; the three chief racial groups are the Sinhalese, Tamils and Moors. Education in Ceylon is compulsory and there are more than 3,000 schools and colleges. 12,737 boys and girls, aged 5–18 and belonging to various races and of various social origins, were weighed and measured. It was found that the height and weights means of children of the well-to-do classes were higher at all ages than those of the middle and poorest classes, those of the poorest classes being the lowest. Averages in the various social classes were much the same in each racial group, and it may probably be assumed that the most important factor affecting development is diet. Investigation showed that the diet of children of the poorer classes in the vernacular schools is very deficient in quality.

A diet survey of 15 peasant families was carried out, intake of calories and proximate principles worked out as follows:—

* By Lucius Nicholls, M.D., B.C., B.A., *Ceylon Journal of Science*, Vol. IV., Part I (April 21, 1936).

Protein (g)	Fat (g)	Carbohydrate (g)	Calories
55·5	32·0	365	1,942

The author suggests that "a diet of the value of about 2,200 calories is sufficient for the requirements of an agricultural labourer belonging to the smaller races of the tropics, provided the diet is well-balanced in necessary constituents."

Infantile mortality is high in Ceylon (176 per mille during the decade 1923–33). Among the most important causes of death are those entered in the returns as "debility" and "convulsions"; in the author's opinion, malnutrition is the basic cause of the majority of deaths entered under these heads. A large number of infantile deaths from a condition called "mandama" are registered; "mandama" is characterised by a papillar skin eruption, weakness of the limbs, and extreme wasting. Many patients with "mandama" have "sore-mouth", a condition now recognised to be due to diet deficiency, and eye signs and symptoms including xerophthalmia and keratomalacia. Dental carries and irregularities of the teeth were found to be more common in poor than in well-to-do children, and it seems probable that the high incidence of dental defects in the former is due to malnutrition.

The author discusses the relation between the recent malaria epidemic and nutrition. The epidemic was preceded by a drought, and after a partial failure of the rains of the north-east monsoon, drought conditions continued during the greater part of the epidemic period. The conclusion seems to be that "even if the masses had been well fed and prosperous, there would have been an epidemic of malaria, but the vicious circle of malaria and destitution acting and reacting on one another would not have been established, and the mortality rate would have been lower. Convalescence would have been shorter, and probably the infectivity and relapse rates would have been less."

Hookworm is common in Ceylon. It is estimated that 90 per cent. of the lower classes in Ceylon are harbouring on an average about 90 hookworms, which will withdraw about 9 c.c. of blood daily from the host. The presence of hookworm in the intestine must increase diet requirements, particularly in respect of iron and first class protein, to make good the steady loss due to withdrawal of blood.

Dr. Nicholls' survey should be closely studied in India, for nutritional conditions in Ceylon do not greatly differ from those existing in many parts of India. Preliminary surveys have shown that the various food deficiency diseases occurring in Ceylon are also, as might be expected, common in South India.

The Ceylon survey re-emphasises the paramount importance of nutrition in relation to public health in the East.

W. R. A.

CENTENARIES.

S. R. Ranganathan, M.A., L.T., F.L.S.

Fahrenheit, Gabriel Daniel (1686-1736).

FAHRENHEIT, the German Physicist, was born at Danzig on May 14, 1686. Having received his early education at Amsterdam, he travelled widely in England, Denmark and Sweden. His business was the manufacture of meteorological instruments; but he became deeply interested in physics, as a result of his close association with Olaf Romer, whom he probably visited in Copenhagen during 1709.

MERCURY THERMOMETER.

"Finding, in the history of the Royal Academy of Sciences, that M. Amontons had, by means of a thermometer of his own invention, discovered that water boils with a fixed degree of heat," Fahrenheit "was very desirous of making such another thermometer, to view with his own eyes this curious phenomenon of nature, and be convinced of the truth of the experiment. And recollecting what sagacious inquirers into nature had

written.... he imagined, that perhaps a thermometer might be made of mercury. Having made such a thermometer, though still imperfect in several respects, the event answered his expectation, to his no small satisfaction." He invented a successful method for cleaning mercury and was the first to bring about the general use of mercury in thermometers. With the aid of his thermometer, he made a series of tests on liquids other than water and found that each had a fixed boiling point.

FAHRENHEIT SCALE.

First he worked with thermometers filled with spirit of wine. He took two fixed points. "The first, the lowest.... is found by a mixture of ice, water and sal-ammoniac or sea-water; if the thermometer is dipped in this mixture, then the liquid falls to the point marked 0. This experiment succeeds better in winter than in summer." "The second is that point to which the alcohol expands if the thermometer be held in the mouth or armpit of a healthy person." He divided the interval first into 180 equal parts and later, into 96 parts. In 1724 he introduced a third point which corresponds to a mixture of ice and water alone. Later when he began to use mercury, he took, in the place of the temperature of the human body, the boiling point of water. On his scale, this happened to be at 212.

HONOURS.

Fahrenheit attained considerable celebrity by his investigation. In 1724 he was elected a Fellow of the Royal Society of London and contributed five short papers to the *Philosophical Transactions* of the Society. These papers have been reprinted in Heft 57 of Ostwald's *Klassiker*. One of these papers deals with a new form of hygrometer. He died in Holland on September 16, 1736.

* * *

Pond, John (1766-1836).

JOHN POND, English astronomer royal, was born about 1767 in London. His early education was at Maidstone Grammar School, under the tuition of Wales, astronomer to Captain Cook's expedition. His University course was at Trinity College, Cambridge. Due to ill health, which attended him almost through life, he spent several years abroad.

ENTERS ROYAL OBSERVATORY.

Pond's attention was directed to astronomy by Wales. Even when a boy, he detected some imperfection in the Greenwich instruments. Later in life, in the first decade of the nineteenth century, he got an altitude and azimuth circle of Troughton and undertook a series of observations from which he deduced that the quadrant then in use at Greenwich for the determination of declinations had changed its form since the time of Bradley. This brought his name to prominent notice among astronomers and led to his appointment as the head of the Royal Observatory. He soon gave up the quadrant and established a mural circle. "Mr. Pond saw, almost intuitively, the vast superiority of this over every other form of the declination instrument."

HIS CONTRIBUTIONS.

While at Cambridge, he missed the opportunity of acquiring that depth of mathematical knowledge which is necessary for the highest branches of theoretical astronomy. Hence, he devoted his official life mostly to observations and particularly to the determination of the places of fixed stars. Under Pond the instrumental equipment at Greenwich was completely changed. He published eight folio volumes of *Greenwich Observations*, translated Laplace's *Systeme du mon de* and contributed thirty-one learned papers. His catalogue of 1,112 stars, published in 1833, had great value.

HONOURS.

Pond was elected to the Royal Society in 1807 and was appointed Astronomer Royal in 1811. He received many academic honours. As a mere handler of instruments, Mr. Troughton, one of the best critics in such a matter, used to say that Mr. Pond had, within his knowledge, no equal or rival except Captain Kater. The testimony of the Astronomical Society is even greater. "It is not too much to say that meredian sidereal observation (which excludes the Herschalian branch of astronomy) owes more to him than to all his countrymen put together since the time of Bradley."

He retired in 1835 and died at Blackheath on September 7, 1836, and was buried beside Halley in the churchyard at Lee.

Villari, Emilio (1836-1904).

PROF. VILLARI of Naples was born in 1836. From his birth, he suffered from epilepsy. Having taken a degree in medicine at Pisa, he served, for a year, as a teacher in a medical school at Naples. He became the Professor of Physics at Pisa, in 1861. In 1864 he went to Berlin for higher studies in the laboratory of Magnus. From 1865 to 1871, he was Professor at Florence and from 1872 to 1889 he taught at Bologna. In the latter year, he became the Head of the Department of Physics at Naples.

X'd Air.

His chief field of work was in the sphere of radioactivity. His investigations of the properties of "X'd air", *i.e.*, air and gases which have been rendered radioactive by Rontgen rays, are the most noteworthy. He published more than fifty papers in the organs of different learned societies. He was President of the Lincei Academy and an honorary member of the Physical Society of London and of the Royal Institution of Great Britain.

While he was Professor at Naples, his duties involved the conducting of three separate University courses of lectures, in the session of 1902–03. As a result of this, combined with research, he broke down under the stress of work and after a long and painful illness, he died on August 20, 1904.

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Jussieu, Antoine Laurent De (1748-1836).

A. L. DE JUSSIEU, French systematic botanist, was born on April 12, 1748. He was the fourth of a French family which distinguished itself in botany during successive generations from the beginning of the eighteenth century to the middle of the nineteenth. The first of the line was Antoine, eldest uncle of the subject of this note, and he was born in 1686. The last was Adrien Laurent Henri, the son of Antoine Laurent, and he died in 1853.

Born at Lyons and educated at Paris for the medical profession A. L. De Jussieu, came under the influence of his uncle, Bernard, who possessed a profound knowledge of plants. In 1770, he became demonstrator in botany in the Jardin du Roi. This obliged him to occupy himself incessantly with acquiring a correct practical acquaintance with plants.

His Classification.

At that time the collection of plants in the Jardin du Roi was arranged according to the method of Tournefort; but shortly afterwards it became necessary to rearrange it. Of this opportunity Jussieu took advantage; he drew up a memoir upon a new method of arrangement which was read before the Academy of Sciences and afterwards carried into effect in the Garden. It is here that is found the first distinct trace of those clear ideas concerning the relative importance and subordination of characters which the author subsequently applied to the whole vegetable kingdom.

From this time, that is, from 1774 to 1789, Jussieu was constantly occupied in demonstrating to his class of botany, and as his new method was thus brought perpetually before him, with all its advantages and disadvantages, in practice, he was able to alter and improve it from year to year. This continuous ripe experience found its expression eventually in the famous book *Genera plantarum* (1789), which became the basis of modern classification.

His Memoirs.

In 1793, Jussieu became Professor of Rural Botany and later became Director and Treasurer of the Museum of Natural History. After an interval of political distractions necessitated by the Revolution, he recommenced, in 1802, his botanical writings, chiefly in the form of memoirs upon his own natural orders of plants. These, which were nearly sixty in number, appeared regularly in the *Annales du Museum* till 1820, after which time his failing eyesight prevented further work.

His Last Days.

Nevertheless, he employed himself between his eighty-third and eighty-eighth year in dictating a new edition of his *Introduction in historian plantarum*. This work has been published since his death; it is written in elegant Latin and is a remarkable proof of the vigour of his intellect even at this advanced age. He appears to have been much loved by his family and greatly respected by his friends. He died after a short illness on the 15th September 1836, and left behind him a son, Adrien, his successor in the Chair of Botany and the author of *Botanique* which reached nine editions and was translated into many languages.

ASTRONOMICAL NOTES.

1. Comet Notes.—Comet 1936 *a* (Peltier) which attained naked eye visibility about the end of July, has been widely observed. Although weather conditions were generally unfavourable the Comet appears to have been seen by a few observers in India when it was near its maximum brightness. Several computers have calculated orbits for the comet from the observed positions in May and June, but the period cannot be predicted with certainty on account of the divergence from parabolic motion being very small. A more accurate determination will be possible when all the observations during this apparition, including those from the southern hemisphere, are used in the discussion.

The second new Comet of the year (1936 *b*) was discovered on July 17th by Mr. Kaho, a Japanese astronomer. At the time of discovery it was at its brightest—about the sixth magnitude and just visible to the naked eye.

2. The Solar Eclipse of June 19, 1936.—From the available information, it appears the weather was fairly good at many of the stations occupied by observers on the line of totality, although one of the British expeditions (under the leadership of Prof. Stratton) met with unfavourable weather at Hokkaido (Japan). Brief statements from some of the parties have been published, which indicate that the Corona was very bright and a type intermediate between maximum and minimum. Five brilliant prominences, it is stated, were seen during the total eclipse, and coronal arch structure was visible above one of the largest prominences. It will be some time before the detailed results are available from the several parties of astronomers who observed the eclipse.

3. The Rings of Saturn.—The earth passed very near the plane of Saturn's rings on June 28, 1936. Observing with the 36″ refractor of the Lick Observatory, J. H. Moore reports that the rings did not disappear entirely, but were clearly visible, about that time, as a fine bright line to the east and west of the planet.

4. New Stars.—Both *Nova Herculis* and *Nova Lacertæ* are easily visible at present with binoculars and small telescopes. *Nova Lacertæ* is declining rapidly, its magnitude being 8·4 on September 9. From spectroscopic observations its behaviour is found to be in general, like other novæ, but the absorption lines show remarkably large displacements. Merrill and Wilson have measured the intensities of detached lines in the spectrum of the Nova and have estimated its distance to be about 800 parsecs.

5. Mass Ratios of Sirius and τ Cygni.—Prof. Van de Kamp has made a new determination (*Astronomical Journal*, 1049) of the mass ratios of these two important binary stars from measures on a long series of photographs taken for parallax work at the Leander McCormick Observatory. In the case of Sirius the masses obtained are 2·6 for the bright star and 1·3 for the companion (taking the mass of the Sun as unity) while for the components of τ Cygni the masses are 2·4 and 0·8 respectively.

T. P. B.

OBITUARY.

Lieut.-Col. R. Knowles, C.I.E., I.M.S.

WE regret to have to announce the death of Lieut.-Col. R. Knowles, C.I.E., I.M.S., which occurred in the early hours of the morning of August 3rd at the Carmichael Hospital for Tropical Diseases, Calcutta.

Robert Knowles was born on October 30th, 1883, in India where his father was a missionary. His early education was at Mill Hill School. He went up to Cambridge (Downing) in 1901; here he took his arts degree and commenced his medical studies. From there he went to St. Mary's Hospital, London, and in 1907 took his qualifying diploma, the M.R.C.S., L.R.C.P. It was at St. Mary's Hospital where he worked under Sir Almroth Wright that Knowles first acquired a taste for medical research which was to be the dominating influence of his whole life. He took the I.M.S. entrance examination in 1908 and passed into the service at the top of his batch. After four years of military service he achieved his first ambition, and was put into the then-newly-formed Bacteriological Department which afterwards became the Medical Research Department.

He was posted as Assistant Director at the Pasteur Institute, Kasauli. Here he came in contact with a number of people who had a considerable influence on his life and work—Harvey, McKendrick and above all Acton. His first work was carried out with Acton as his collaborator and together these two workers published some important papers on the action of snake venom, on halteridium in pigeons and on other subjects; the first volume of the *Indian Journal of Medical Research* contains eight papers by them. Knowles always maintained his interest in snakes and snake venom, although he had little chance of doing further work on the subject, and the work on halteridium gave him an introduction to protozoology, a subject of which he later became a master.

His work at Kasauli was interrupted by the War, and he was sent to Mesopotamia with the 11th Mahratta Light Infantry. He was wounded very badly in the leg in the battle of Ctesiphon and was mentioned in dispatches, and after a long stay in hospital in India and later in London he was posted as Bacteriologist to Cumballa War Hospital in Bombay. As his leg wound had incapacitated him for active field service he was later transferred back to civil employment and was sent to Shillong to open the Pasteur Institute there. This was Knowles' first independent responsible post and he made a very great success out of it. The anti-rabic treatment was only a small part of the functions of the Institute. It was practically the only laboratory in the province and it had to be organised to deal with an enormous amount of routine laboratory work. And this was not all; at that time kala-azar was beginning to increase alarmingly in Assam and Knowles established a kala-azar ward and carried out an investigation on the treatment and on many other aspects of the disease. He worked out a scheme of dosage with sodium antimony tartrate—a drug that Sir Leonard Rogers had just introduced; this scheme was followed for many years in Assam until the new pentavalent compounds came into general use.

It was during this time at Shillong that Knowles met Sir Leonard Rogers; it had been at the latter's suggestion that he started the work on kala-azar. When Sir Leonard left India in 1920 he selected Knowles as his successor at the Medical College. He also left him the far more arduous task of starting the School of Tropical Medicine. Knowles decided to devote the whole of his energies to the latter task; he was appointed Secretary of the School and with the aid of Colonel Baptist (then Captain) organised the staffing and equipment of this large and important institution. The next year when the School opened he was appointed Professor of Protozoology, and he held this appointment until his death nearly sixteen years later.

He was determined that his classes in protozoology should be a success and he devoted an enormous amount of time and trouble not only in preparing his lecture notes but in collecting material from all over the world for demonstration specimens and for issuing to the practical classes. In 1923 he published his lecture notes in the form of a book which the students of the earlier years at the School found invaluable.

This would have been full-time occupation for most men but Knowles with his unbounded energy found time to carry out

many important research investigations. He maintained his interest in kala-azar and actively co-operated in the research that was being carried out on the transmission of this disease. The paper that he wrote with L. E. Napier and R. O. A. Smith on the development of leishmania in the sandfly, *Phlebotomus argentipes*, opened a new phase in the investigation of this subject. It would be out of the question here to attempt to enumerate the various investigations which he carried out in the realm of medical protozoology; his published papers covered a wide field, reporting investigations on trypanosomes, leishmania, spirochætes, amœbæ, intestinal flagellates, and human and simian plasmodia. During his last years he carried out some very important investigations on monkey plasmodium, a strain of which, first discovered at the Calcutta School by some of his associates and distinguished from other simian plasmodia by Sinton, was named after him, *Plasmodium knowlesi*. He and his valued assistant Biraj Mohun Das Gupta were the first to transmit this plasmodium to man. This strain has recently been used in the treatment of neurosyphilis in Europe.

Perhaps, Knowles will be best known for his excellent book on medical protozoology. For many years there was no satisfactory book on this subject for the student and it was always Knowles' ambition to provide one. In the first few years at the School he felt that there were too many gaps in our knowledge to make a book on the subject worth while; he thought that it would be out of date before it was printed. However, at the beginning of 1927 he felt that the time had come to put his notes together and to fill in the gaps, and by the end of the year he had completed the manuscript for his book which he modestly called an *Introduction to Medical Protozoology*. When he had written more than half the book, Wenyon's classical work on this subject came out and Knowles wavered in his intention, but he considered that Wenyon's book did not quite meet the needs of the Indian student and he decided to finish his own book. The new matter which Wenyon's book presented made it necessary for him to expand and even re-write some of the sections that were already finished. The writing of this book was a gigantic task which he completed in an incredibly short time.

Other important books that he wrote were *On the Dysenteries of India* with Acton and on malaria with Mr. S. White.

On a number of occasions he officiated as Director of the Calcutta School of Tropical Medicine.

He was Assistant Editor of the *Indian Medical Gazette* from 1922 to 1928 and Editor from 1928 to 1932; he devoted a very great deal of his time to editorial work and he did much to raise and to maintain the standard of this journal. He was a most facile and lucid writer, and his output was enormous.

During the last few years of his life ill health curtailed his activities; however even then he was not content just to do his routine duties and in 1934 he undertook the task of writing a comprehensive review of the work of the School of Tropical Medicine during the previous twelve years.

He was President of the Medical Section of the Science Congress in 1930 and his presidential address on the evolution of medical protozoology was an excellent example of Knowles' best work; it has frequently been quoted in this and other countries. He was always a great supporter of the Asiatic Society and he was for a long time Medical Secretary, and later for a number of years a Vice-President of the Society.

He was a Foundation Fellow and was also on the Council of the National Institute of Sciences of India.

He was given a C.I.E. in 1935, an honour which many of his friends considered he should have earned many years earlier.

The medical profession and medical research in particular have suffered a great loss through his untimely death.

L. E. NAPIER.

Scientists and War.

"THERE are three lusts which are present in the subconscious mind of man which lie at the basis of war, the lust of *power*, the lust of *prestige*, and the lust of *possession*." These remarks were made by Dr. Gilbert J. Fowler in the course of his presidential address at a discussion on "Moral responsibility of scientists in modern warfare," held at Bangalore on 22nd August, under the joint auspices of the Society of Biological Chemists, India, and the Institute of Chemistry. Sir Martin Forster, Mr. Ernest Kirk, Rao Bahadur Prof. B. Venkatesachar and Prof. C. R. Narayan Rao took part in the discussion.

In the course of a thoughtful address, Dr. Fowler observed, "My scientific and professional work has brought me in contact with chemists and engineers all over the world including Moscow and Japan. I may, therefore, claim to be something of a citizen of the world and can have no desire to hate or destroy the many good friends I have made.

My experience will, in some degree no doubt, be that of many other scientists and therefore, the scientist is pre-eminently fitted to be a friend of all the world.

If, however, this worthy ambition is to be realised, it would seem necessary that certain commonly voiced statements and their implications should first be criticised.

One view which is gaining ground is that the discoveries of scientists are themselves largely the cause of war. The fallacy of this will be evident after a moment's thinking.

It is often apparently assumed that poison gas or chemical warfare is due to the secret and devilish investigations of chemists. Actually I believe practically all the gaseous weapons, used in the war, had been discovered previously in the course of purely peaceful investigations.

Another statement constantly made is that war is *inevitable*. This is to mistake the fundamental causation of things. Guns do not attack the enemy automatically, their construction and operation depend obviously on the living mental agent behind them. Therefore it is with this mind that we have to deal. Even if this be granted, however, another frequent statement is that *human nature does not change*. This statement may contain a certain measure of truth but even if human nature doesn't change there need not be so much of it. I would remind you that the rate of scientific progress during the last 100 years has been something altogether exceptional in the history of the world. May we not believe that just as the chemical experiments of Roger Bacon were at the time looked upon as a species of black art, but are now part of the possible knowledge of every Board School child, so certain fundamental spiritual truths, the knowledge of which was supposed to be confined to a few saints, sages and mystics, may become the common property of humanity? The evil power of mass suggestion is only too evident. As the Bishop of Calcutta has so well argued "why cannot the voice of truth be equally well disseminated among the people of the world?" In this connection one might refer to another apparent assumption, that men of science are superior to war suggestion. I am afraid, as an American might say, "I should smile." I have not observed that men of science are much less quarrelsome than other people. Personally I have not found that the study of chemistry has in itself enabled me more easily to control my temper or to suffer fools gladly.

Another assumption would seem to be that peace and democracy were desirable things to which all had a right much as we have to air and sunshine. On the contrary they are the rewards of great and persistent effort. Peace is the reward of righteousness. Democracy is the reward of self-discipline.

Another half truth is that war is due to a shortage of raw material on the part of certain nations. There is no shortage, *e.g.*, of tea. The Indian tea planter would be only too glad to sell as much as he could to anybody. It is not the present shortage but the fear of possible future shortage in case of war which is the trouble. Why then have War?

Actually the root cause of War lies deeper than these material difficulties. I would say that there are three lusts which are present in the subconscious mind of man, which lie at the basis of war, the lust of *power*, the lust of *prestige* and the lust of *possession*. These are all characteristic of the vulgar parvenu. I should like to read to you in contrast some words from one who cannot be accused of being a pacifist.

> "Greatness consists in not being the echo of others, in not throwing dust in anyone's eyes, in seeking only what is necessary for the welfare of the country and making straight for the goal..... All kinds of obstacles will be put in your way; but in the conviction that you are not great, but small and weak, and expecting no help to reach you from any quarter, you will, in the end, surmount all hindrances. And if any man, after that, calls you great, you will simply laugh in his face."

These are the words of Mustapha Kemal and I would remind you that he has made a nation out of Turkey, and that he has got his way in the Dardanelles without a single threat.

Another Dictator has made much play with the idea that war is a school of character. No doubt, great qualities are exhibited during war, so they are during earthquakes, floods, shipwrecks and mining disasters. Yet we do not look upon these as blessings. I cannot do better than quote again, this time from our King Emperor who spoke as follows after reviewing the Guards:

> "Humanity cries out for peace and the assurance of peace, and you will find in peace opportunities of duty and service as noble as any that bygone battlefields can show."

Let us not, therefore, as men of science make use of any of these half truths in our campaign for the abolition of war. I say for the abolition of *War* because the abolition of any particular weapon is only a part of our task. While it is arguable that there is little to choose between death or torture by poison gas and being smashed by a shell, it must be recognised that throughout the history of humanity certain limits have always been instinctively laid down. This was so even in the old Mosaic law and is implicit in the common expression "hitting below the

belt". Most people would sooner face a revolver than a bottle of vitriol.

Any joint effort, therefore, which can be made by the scientific workers of the world to limit the use of methods of warfare which involve death and torture to innocent and unprotected people is to be welcomed.

Nevertheless, the intelligence which is capable of investigating the furthest star or the smallest molecule, that has discovered means of communication which have annihilated space and time, can surely produce some result if it will honestly and humbly set itself to the study of these infernal forces which lie in the subconscious mind of man, and which need to be controlled by some higher energy if all the fair prospects of humanity are not to be obliterated in one hideous ruin. The famous psychiatrist Dr. Jung says "it is the psyche of man which makes wars.....the most tremendous danger that man has to face is the power of his ideas. No cosmic power on earth ever destroyed ten million men in four years but man's psyche did it *and it can do it again*. I am afraid of one thing only, the thoughts of people. I have means of defence against things."

The following resolutions, put forward from the chair, were passed by the meeting:

"This meeting while pledging its support to every united effort which can be made to abolish methods of warfare which are repugnant to the common instinct of humanity recognises that the more important objective is the abolition of war itself.

To attain this end it would urge constant and strenuous activity on the part of thinkers and men of science.

In particular it records its opinion that more attention should be given by them to the study of the new economic conditions, which of necessity, accompany the advance of scientific research.

Of equal or greater importance is the study of means for controlling the evil effects of "mass suggestion," by the more powerful agency of widely disseminated right ideas through the adoption of an international system of education."

Rabies—A Note.

By S. P. Deshpande, G.B.V.C.

(*N. S. Agricultural College Veterinary Hospital, Poona.*)

RABIES is a very common and most unfortunate disease in Veterinary practice, especially in dogs. No attempt at treatment or relief can be made. If anything in the form of narcotics is given, it is likely to mask the characteristic symptoms and make diagnosis more difficult. Either the patient is allowed to die a natural death or destroyed when diagnosis is established beyond doubt.

In this article, the writer wishes to record certain symptoms of rabies which one comes across in daily practice. The symptoms of rabies, especially that of dumb form, are varied and are likely to escape one's notice, unless one has extensive practical experience.

There being no legislation about the control of stray dogs, this disease is playing a havoc taking a heavy toll of dogs and cattle in this country. Rabid cattle are not generally brought to hospitals. Dogs which are pet animals are generally brought to hospitals especially in cities; this disease is commonly observed among them. It is really a great menace to the dog world and in turn to human beings too. Costly and well-bred dogs stand a great chance of getting infection in spite of every precaution taken by the owner. For instance, a dog is being taken or led for a walk; some stray dog comes all of a sudden, bites it and disappears keeping the owner in doubt as to what type of dog it was: rabid or normal. We have had many such cases.

At this hospital, we have seen cases of rabies in horses, cows, buffaloes, sheep and goats, and dogs; in the latter we get a number of cases all the year round.

There are two forms of this disease, *viz.*, furious and dumb. Furious form is very easy to detect and the symptoms are clear, *viz.*,, changed appearance, silly look, very red eyes and rushing at every object which comes into view. Such dogs do a great deal of damage biting several persons and animals and thus spreading infection. In cases of furious form, the writer has observed that the dog said to disappear from the owner's house for two or three days, come back with the symptoms described above in a most exhausted condition biting everything that comes across, in the compound. In this form dogs are seen eating their own fæces. If allowed, to live, these furious symptoms are followed by exhaustion, paralysis and death. Several cattle are infected by a dog suffering from this form of rabies. This is how cattle get infected.

In the dumb form, variety of symptoms are observed. Melancholy stage is common to both the forms and is generally passed unnoticed, duration being short and also being not in any way very diagnostic in the first instance; but when the disease advances, pronounced symptoms are shown and they will be as follows:—

> Uneasiness of a very peculiar type, congestion of conjunctiva, salivation from mouth, drooping of the head, changed behaviour, paralysis of the lower jaw, tongue of a lead colour, vague and listless expression, incoordination of the hind limbs, which afterwards develops into complete paralysis. Eyes sink. The animal is prostrate, breathing very heavily, gets convulsions, breathing becomes more distressing and sterterous, becomes exhausted and dies.

Wasting of muscles is very rapid in rabies so much so the dog becomes almost a skeleton in a few days' time. In many cases' appetite is totally suspended; but in some, the animal tries to lap and eat up to the last. In some cases, simply dry retching of a peculiar type and

uneasiness is noticed. The animal retches oft and on and a peculiar noise is produced. In some cases, simply a vague expression and slight change in behaviour are noticed for four or five or even more days and then sudden death with convulsions takes place.

Very rarely, the disease developes as a complication in another disease and that is generally distemper. The only explanation for such an occurrence is that the patient must be pre-infected and this disease coming up as a matter of loss of vitality or predisposition due to the original disease. We had one case with typical symptoms of distemper which was treated as an out-patient for some days. After some days' treatment, the patient showed symptoms of rabies and died; the brain was sent for microscopical examination and the case was confirmed as rabies. Temperature in almost all cases is elevated, in some cases upto 106° F. In some cases acute uneasiness is noticed and the animal does not rest in one position for even a few seconds. In such cases, death may take place within 24 hours.

In the case of dogs, males are affected more than the females—probably the former being fighters are liable to be exposed to infection.

Very small puppies, even two months old, are also affected. We have seen two cases of furious rabies in small pups.

In the case of cattle, it is observed that the disease comes up just after calving.

Also the place and depth of bite wound are points worth considering. The deeper the bite and the nearer to the brain, the greater the possibility of developing the disease. We have seen cases bitten on the nose and head to develop the disease within 25 days from the date of bite. Superficial bites elsewhere on the body have remote chance of causing infection. Also the quantity of poison injected is a factor worth considering; but unfortunately, this cannot be estimated.

Before concluding, it would not be out of place to mention some diseases which show at times the same symptoms as that of rabies and are likely to be mistaken for rabies *prima facia*.

(1) Sticking of bone in the throat: dry retching, salivation and uneasiness. (2) Acute Rheumatism: uneasiness, peculiar gait and animal snapping on palpitation. (3) Advanced cases of canine typhus: mouth held open due to ulceration of buccal membrane, salivation and exhaustion. (4) Milk apoplexy: uneasiness, dullness, gasping due to high temperature and suddenness of attack. (5) Ordinary convulsions of epilepsy when the animal is brought to hospital in the last stage and without history. (6) Very severe form of skin diseases. Irritation of the skin produces sometimes the same train of symptoms. (7) Severe form of canker, making the dog uneasy and to run with the head held low and flapping of ears. Even salivation is seen. (8) Motor or Cycle accident cases with no fracture but simply a smash: their wavering gait, salivation and dullness. (9) Nervous form of distemper. (10) Dislocation or paralysis of the lower jaw. (11) Vicious temperament. (12) Phosphorus or strychinine poisoning.

Résumé on the Literature of Indian Medicinal Plants.

By K. Biswas, M.A.

(*Royal Botanic Garden, Sibpur, Calcutta.*)

FREQUENT demands for characterisation of medicinal plants, for furnishing accurate information as to their distribution and life-history and for the supply of authentic specimens of genuine medicinal value, have led the writer to prepare a treatise on medicinal plants which will be published in due course. Attempts have been made from a very early period—as early as the Vedic period—to supply a work of such vital importance. Indeed, the origin of botanical science may be traced to the investigation of the medicinal properties of plants. Search for the healing properties of plants to mitigate the misery of human beings caused by various ailments led to the serious study of the plants around them. Thus developed the science of Ayurveda which forms an important part of Atharva Veda—the most ancient and celebrated treatise on Hindu medicine, although, the use of some plants is mentioned earlier in Rig Veda.

The works of Agnivesha, one of the six distinguished pupils of Ayurveda, resulted in the compilation of *Charaka-Samhita* by Charaka. *Sushruta-Samhita* then emanated from the pen of Sushruta, one of the brilliant disciples of Dhanvantari, the surgeon of heaven who took his birth in this country as Divadasa, King of Benares, who was reputed for his extraordinary knowledge in surgery and medicine. Thus *Charaka-* and *Sushruta-Samhitas* are the oldest treatises now extant and are of such great value to the Hindus that they are considered to be divine and beyond criticism. Among the contributions of this early period mention may be made of Bagbhatta's *Astanga-hridaya-Samhita*; *Chakradatta-Sangraha*; *Sarangadhara-Sangraha*; Vab Misra's *Vab Prokasa*; Madan Pal's *Raj Nighanta* and several other *Nighantas* and works on *Drabya Gunas* formed the basis of further studies on medicinal plants. Works of Makhzum-ul-Adwiya and other Hakims written in Persian and Urdu may be mentioned as valuable contributions to medical science in those old days by Mahommedans.

Foreign influence on the study of plants either for purely theoretical interest or for information on their medicinal values, dates back to the sixteenth century when Portuguese and Dutch scientists came to India. They may be considered as the pioneer workers in this field. Thomas Rives, Odardo Verbosa, Christobal DaCosta are among those who took lively interest in the study of drugs. But along with these it

will be necessary to include Garcia da Orta, whose *Coloquios dos simplas e drogas Le cousos medicinais India*—was published at Gôa in April 1563 and was in fact the third book printed in India. Van Rheedes' *Hortus Malabaricus* is the monumental work of twelve volumes on the study of Indian plants in the 17th century from 1678 onwards to 1703. During the 18th and 19th centuries, valuable contributions based on researches carried out on more or less modern lines, were made by a band of highly trained workers which enabled the recent investigators to make sufficient headway in the study and investigation of medicinal plants of this country. The earliest work of the 18th century of sufficient value is that of Georgens Everhardus Rumphius' *Het Amboinsch Kruyd-Boek* (1750). It was actually written by Rumf in the 17th century and the manuscript was left unpublished in the archives of the Dutch East India Company until Burman received permission to publish it. The name of William Roxburgh, " the father of Indian Botany "—the first Superintendent (1793–1813—whose book on Indian plants was actually published in 1820–1824 by Dr. Carey) of the then East India Company's garden—now, The Royal Botanic Garden, Calcutta, has become a household word in this country in recognition of his inimitable *Icones* and his *Flora Indica*. His works form the keystone for subsequent works on Indian plants. To confine ourselves mainly to the study of Indian medicinal plants—the names of the following workers may be mentioned: Dr. Fleming (1810), W. Ainslie, author of *Materia Medica of the Hindus* (1813) and its second edition—of 2 octavo volumes on *Materia Medica* (1825); Playfair (1833), Talif Sheriff, *Indian Materia Medica*, published in Calcutta, 18th to 19th century; Forbes Royle, *Vegetable Resources of India* (1839); and Sir William O. Shaughnessy of the Calcutta Medical College, who published in collaboration with Dr. Nathenial Wallich—next successor to Roxburgh as the Superintendent, Royal Botanic Garden, Calcutta—his much reputed work entitled *The Bengal Dispensatory and Pharmacopœia* (1844). Shaughnessy's publication led to the recognition of the value of many of the Indian medicinal plants by foreigners. Next followed Dr. Edward Balfour's *Cyclopedia of India* (1855)—a supplement to which was published in 1862. In the same year G. C. Birdwood wrote an account of *Vegetable Products of Bombay*. *The Useful Plants of India* by Heber Drury of Madras Army (1858–1869); Dr. Stewart's *Punjab Plants* (1869); Atkinson's *Economic Products of North-Western Frontier Provinces*; Dr. George Bidie's *Cinchona Cultivation in India* (1878); U. C. Dutt's *Hindu Materia Medica* (1870) written with the valued assistance of George King, the then Superintendent of the Royal Botanic Garden, Calcutta; Kanny Lall Dey's *Indigenous Drugs of India* (1896) and the notable contribution of B. C. Gupta's *Vanaushadi Darpana*—the second edition of which appeared in 1917 (1324 B.S.), which appeared at the end of 19th century, are valuable contributions during the 18th and 19th centuries. But this period cannot be passed without mentioning the publication of Dymock's *Vegetable Materia Medica of India* (1883) and particularly *Pharmacographia Indica* (1890–1893) prepared in collaboration with Warden and Hooper; and Sir George Watt's *Dictionary of the Economic Products of India* in 6 volumes (1889–1893)—Index volume of which appeared in 1896—are the two outstanding works containing valuable information. These works embody the results of the labours of the two well-known investigators of the latter part of the 19th century. Their contributions will prove invaluable for research workers in their further investigations in this field. In 1918 the voluminous works on medicinal plants by Kirthikar and Basu were published, wherein the authors have made a praiseworthy attempt to compile a detailed description of plants together with notes on their medicinal value. A revised edition of this work with considerable emendations and modifications is ready for publication. The illustrations accompanying the text are of considerable advantage for the identification of the plants. Apart from this work, *Indian Materia Medica* by K. M. Nardkarni—a revised edition of which appeared in 1926—deals exhaustively with the medicinal properties of plants. The botanical aspect of this book requires to be corrected and improved upon. Col. R. N. Chopra, in his book on *Indigenous Drugs of India* (1933) has furnished up-to-date information on the medicinal properties of plants. The botanical information on individual species might have been incorporated with advantage to render this work to be of more general and practical value. The need for bringing out suitable publications to remedy the deficiency of botanical information in treatises on medicinal plants will be appreciated. In the volume now under preparation, the family characters and specific descriptions are given; suitable illustrations and notes on distribution together with brief references to their medicinal properties have been incorporated. It is hoped that this hand-book may serve as a guide both to the professionals and to the amateurs in gathering authentic materials in the field and in identifying medicinal plants. Sir David Prain's *Bengal Plants* proved useful to the author in his work. For valuable suggestion and addition of specific descriptions of plants common to this Province—specific descriptions which fill a gap in such publications as *Bengal Plants*, as stated by Sir David himself—the author offers his grateful thanks to Sir David Prain, Lt.-Col., Kt., C.M.G., C.I.E., M.A., D.Sc., LL.D., F.R.S. I am indeed deeply indepted to Sir David Prain also for making necessary emendations in this contribution. My thanks are also due to Babu Ekkari Ghose, author of *Krisitatwa* for his valuable assistance in the preparation of the book on medicinal plants.

RESEARCH NOTES.

MATHEMATICAL AND PHYSICAL.

A Condition for the Complete Reducibility of Representation of Finite and Infinitesimal Groups.—Brauer (*Math. Zeit.*, **B. 41**, 330–339) has given a set of conditions for all representations of a group (it may be a half group—*i.e.*, the associative law of multiplication holds and the existence of an inverse element of an element need not be true) to be completely irreducible. If G is the group, then the condition he gives is that it is sufficient for complete reducibility of *all* representations, if the same is true for all representations $H = \begin{bmatrix} A & O \\ E & D \end{bmatrix}$, where A and D are irreducible, *i.e.*, he has reduced the problem to the case where the representation consists of only two irreducible parts. The method of proof can also be applied to obtain a set of conditions for the complete irreducibility of a given representation (not *all*). He also proves the corresponding theorem for infinitesimal groups. With the same method he obtains that all representations of a half-simple infinitesimal group are completely reducible, a result which was proved earlier by Wander Waarden and Casimir, by infinitesimal methods using known formula about the structure of such a group. His methods of proof are simple and makes use of elementary results from the theory of group representations.

K. V. I.

On Certain Tamberian Theorems, with Asymptotic Values of Exponential Character.—Avakumovic and Karamata (*Math. Zeit.*, **B. 42**, 345–356) have obtained certain sharp results concerning the asymptotic relation between the value of the Laplacian transform

$$J(\sigma) = \frac{1}{\sigma} \int_0^\infty e^{-\sigma t}\, d\{A(t)\} \text{ and } A(t).$$

Such kind of problems were at first considered by Hardy and Ramanujan. The authors have proved that if $J(\sigma) = Ax^k e^x$, then

$$\log A(t) \sim 2\sqrt{t}. \quad \{\sigma = \frac{1}{x} \to 0\}.$$

They have also obtained the finer inequality

$$\log A(t) = 2\sqrt{t} + 0\,[t^{\frac{1}{4}}\sqrt{\log t}],$$

with the assumption that $A(t)$ is monotonic. (A less stringent condition also is sufficient.) Certain generalisations of these theorems are also given. The authors are publishing as part II their results when

$J(\sigma) = e^{x\alpha} L(x)$ [1 + 0 (1)]. Where $L(x)$ is a slowly increasing function.

K. V. I.

Measurement of the Angular Momentum of Light.—It follows from the electromagnetic theory of light that a beam of polarised light exerts a torque on a plate of doubly refracting crystal which alters its state of polarisation. The same quantitative result is obtained if an angular momentum of $\frac{\hbar}{2\pi}$ is ascribed to a quantum of left-circularly polarised light. This torque has been now experimentally detected in spite of its smallness by Richard A. Beth. Details of the experiment are given in his paper in the *Physical Review*, 1936, **50**, 115. The underlying idea was to send a beam of suitably polarised light through a quartz wave plate which was suspended in vacuum by means of a fine quartz fibre. To increase the torque acting on the plate, the light, after passing once through the suspended wave plate, was reflected so as to pass again through the plate in the opposite direction. The whole apparatus was mounted on heavy cast iron brackets attached to a brick pier. The one inch circular wave plate was hung up by means of a quartz thread 25 cm. long hanging in a quarter-inch hole bored through a copper cylinder of two inches diameter. The upper end of the fibre was attached by means of shellac to a ground conical stopper which fitted the cylinder and was made air-tight with Apiezon grease. Light from a three-millimetre tungsten ribbon filament F was focussed by a fused quartz lens L through a large Nicol prism N and then through a fixed quarter wave plate B which was attached outside the vacuum chamber in a brass ring so that it could be rotated by known amounts. The light then passed through a fused quartz window W at the bottom of the vacuum chamber, then through the suspended plate M and came to a focus at the aluminium reflecting layer at the top of another fixed quarter wave plate T above M. The suspended plate itself was a half-wave plate for that wave-length λ_0 for which B and T were quarter-wave plates. The axes of M were at right angles to those of B and T. The light path was not more than 10° to the vertical at any point while the axis of the light beam was vertical. The rotation of the plate M was observed by means of a small mirror m attached to the fibre and a telescope and scale arrangement. With this arrangement no light energy reached the fibre and most of the light was reflected out of the vacuum chamber so that fluctuations due to unequal heating of the fibre and the light pressure on the small mirror m were minimised. The effect of other wave-lengths than λ_0 was also calculated. The results of about 120 observations showed that the torque observed was of the sign and order of magnitude required by theory.

T. S. S.

On a Simple Nuclear Model.—Treating the nucleus as a gas obeying Fermi Statistics and consisting of protons and neutrons, K. Bechert has developed a simple theory (*Zeits. für Physik.*, 1936, **101**, 721) which correctly gives the variation of the chemical atomic weight A with the nuclear charge Z. The potential energy of the neutrons is taken as $V_\nu(r) = -C$ for $r \leqslant a$ and 0 for $r \geqslant a$. The radius of the nucleus 'a' is set equal to $a_\rho \sqrt[3]{A}$ where A is the atomic weight and a_ρ should be of the order of 10^{-13} cm. The potential energy of the protons V_π is supposed to consist of two terms, one V_c due to the Coulomb repulsion between protons and another $V_{\pi N}$ due to the attraction between protons and neutrons. V_c satisfies the Poisson equation while $V_{\pi N}$ is taken to be $= -C$ for $r \leqslant a$ and 0 for $r \geqslant a$. The essential boundary condition is taken to be that V_π should be finite at $r = 0$. With these assumptions the final formula is deduced that

(1) $\frac{A}{Z} = 2 + 0{\cdot}600\,\zeta^{2/3} + 0{\cdot}115\,\zeta^{4/3} + 0{\cdot}019\,\xi^2 +$

where $\zeta = \frac{Z}{125{\cdot}4033} < 1$ and $\xi = \frac{ar}{\mu}$ with $\mu = \frac{3^{2/3}h^2}{2^{13{\cdot}3}\pi^{4/3}\, m\, e^2\, Z^{1/3}}$.

The theory also gives the formula

(2) $\frac{N}{Z} \backsimeq 1 + 0{\cdot}03\,\frac{Z}{\sqrt[3]{A}}$ where $N = A - Z$

which is similar to the equation $\frac{N}{Z} = C_1 + C_2\,\frac{Z}{\sqrt[3]{A}}$ given by Heisenberg. a_ρ comes out to be equal to $5{\cdot}6 \times 10^{-14}$ cm. so that the nuclear radii come out to $2\frac{1}{2}$ times smaller than those given by Gamow. The variation of the chemical atomic weight with nuclear charge is however very well represented by the formula (1) deduced from this theory.

T. S. S.

Micro-Luminescence of Chemical Reactions.—The phenomenon of chemi-luminescence, where a part of the energy of reaction appears as light, has been studied extensively in a number of cases, with the aid of spectral and other common devices. By using instead, a highly sensitive photo-electric counter, R. Audubert (*Journ. de Chem Phys.*, 1936, **33**, 507) has now discovered that a large number of common reactions such as the neutralisation of a strong acid by a strong base, are accompanied by an extremely feeble emission of light in the ultra-violet region about 2000 A. The essential character of this micro-luminescence is that the quantum of energy liberated is considerable and of the order of 150,000 cal. per gram mole. Such high values cannot easily be accounted for from the point of view of classical chemical mechanics. The author has tentatively suggested among others that this may be due to privileged collisions between highly activated molecules (collisions of the fourth kind !)

M. A. G.

Geologic Deductions from a Thermal Equation.—It is generally admitted that radio-activity—the chief source of thermal energy—is largely confined to the outer parts of the litho-sphere. Since the rocks that contain the radio-active elements are continuously involved in erosion and deposition, the source of energy is migratory to a certain extent. Such migration of material causes variation in the horizontal and vertical distribution of radio-active elements which according to Justin De Lury (*Journal of Geology*, 44, No. 4) results in differential thermal effects of great importance. After discussing the views held by different authors, he has attempted to derive a thermal equation to explain the causes of the frequent distortion of the sial layer. By a series of arguments he tries to correlate his geophysical ideas with the major problems of petrogeneses. According to him batholiths are large masses of horizontally moving magma, generated not at great depths but at comparatively shallow regions. He also questions the universal applicability of the idea of differentiation, as the only cause for the variation noticed in igneous rocks, and suggests that assimilation may have played an equally important rôle.

BIOLOGICAL.

Androstendiol, a Bisexual Hormone.—Prof. Dr. Adolf Butenandt of Danzig, a world authority on the chemistry of Sex Hormones, has an interesting note in *Forschungen und Fortschritte* (12, No. 17, 218) on the preparation of what he terms a "bisexual hormone," that is, a hormone which on administration to animals is capable of developing both the male and the female sex characteristics. The male sex hormone, Testosteron, is now known to be an unsaturated tetracyclic oxyketone of the formula $C_{19}H_{28}O_2$, while the female sex hormone, Oestradiol, is an unsaturated tetracyclic alcohol represented by $C_{18}H_{24}O_2$. Oestradiol can therefore be theoretically obtained by the simple removal of a molecule of methane CH_4 from Testosteron. It is probable that this transformation actually takes place in nature because a very rich source of Oestradiol is, paradoxically enough, the urine of stallions.

This close chemical relationship of the two sex hormones led Butenandt and his co-workers to consider the possibility of the synthesis of a bisexual hormone. It has been known for some time that the catalytic hydrogenation of Oestradiol saturates its double bonds and yields a product, Hexahydro-œstradiol, which not only has none of the physiological properties of the parent substance but on the contrary exhibits to a slight degree the properties of the male sex hormone. More recently, it has been shown that the introduction of an oxygen atom to a molecule of Testosteron yields a product, Oxo-testosteron, which on administration to female mice induces œstrus.

These experimental results were followed by Butenandt who, starting from Cholestrin, has now synthesised an unsaturated alcohol which he names Androstendiol. This substance on administration to castrated male animals induces in them the development of the male sex organs. The animals also develop the secondary male characteristics. Androstendiol, on the other hand, when administered to a castrated female animal brings about the corresponding development of the female sex characteristics in the animal.

The structural formulæ of these complex substances (given in the original paper) reveal that although their physiological actions are so profoundly different, yet their chemical relationship to one another is very close indeed. Further work on Androstendiol and its transformations is in progress.

EMMENNAR.

Nitrogen Nutrition of Sugarcane.—(U.K. Das, *Plant Physiol.*, 1936, **11**, 251–31 F).—Plots of sugarcane, variety H 109, were grown for 24 months at the Experimental Station in Honolulu at 3 levels of N-fertilisation: 133, 266, 645 lbs. N per acre applied as $(NH_4)_2\,SO_4$. Increased applications of N increase the size of the leaf, the rate of leaf and joint formation and the rate of elongation. N favours tillering and increases the yield of cane, but in the high N series the yield was depressed considerably in the later months because of mortality of cane from lodging. Water, reducing sugars and electrical conductivity of the sap increase with increasing N applications. Sucrose determinations showed that it decreases with increasing N applications. Seasonal variations of these

constituents were greater than those due to treatment alone. Increasing N applications produce no clear cut differences in the polysaccharide content or the pH of the expresssed juice. The higher the application of N, the greater the N content of the cane tissue. The lower the application of N, the more efficiently the cane removes the N from the soil. The medium N series produced a much greater amount of dry matter and sucrose than either the low or the high N series. The variations observed are explained on the basis of the effect of N applications on the absorption of ash constituents which modify the hydration capacity of the tissue colloids. This directly affects the conditions of the soluble compounds of the cell sap and appears to control the relative elaboration of the various carbohydrates in the tissue through its influence on the enzyme complex of the plant.

The Effect of Liming upon the Yield and Quality of Sugarcane.—Somewhat striking results following the application of lime to certain sugarcane soils in the Phillipines are reported in a study by Vicente B. Arancillo (*The Phillipine Agriculturist*, **24**, No. 6). The pH value of the soils before liming was about 6.6 and the application of lime at the rate of a ton per acre brought the pH value up to 7·73. Limed at this rate the germination was found to be better and the crop more vigorous, though the lime had no effect on the maturity of the plants. The yield of cane was the highest on the plot limed at one ton per acre being about 6·4 tons more than the control and about 5·6 tons more than plots limed at the higher rate of four tons per acre. The yield of sugar per ton of cane was however not affected, such differences as were noticed not being significant. Computed in money values the one ton limed plot gave the highest gain while those limed at two and four tons per acre both resulted in big loss. The soils dealt with were heavy clay loams, the lime applied contained 45·86 per cent. CaO and the variety of cane used was POJ 2878.

A. K. Y.

Heat Sterilisation of Mangoes and Guavas for Fruit Flies.—Certain mango varieties and guavas grown in Porto Rico are said to be excluded from importation into the U. S. A. on account of their being infested with the fruit flies and a rather interesting experiment (abstracted in *Exp. Stn. Record*, **74**, No. 4) to get over this difficulty consists in subjecting consignments to heat sterilisation at a temperature of 43° C. in a circulating atmosphere saturated with moisture. It was found that the treatment effectively kills the eggs, maggots and pupæ of the fruit flies without unfavourably affecting the flavour, appearance or keeping qualities of the fruit, provided it is placed afterwards in refrigeration. It was also seen that sterilasation for 4 hours was quite as effective as the 8 hour sterilasation affording thereby a large margin of safety. Mangoes could be freed from infestation whether crated in their natural state or wrapped in paper and crated. The method of course aims only at killing eggs, etc., already inside the fruit and does not relate to the infinitely more important matter of preventing the entry and infestation by the flies. The fruit flies referred to in the study are identified as *Anastrepha fraterculus* and *Anastrepha unipuncta* attacking mangoes and guavas respectively.

A. K. Y.

Haemoproteids of Indian Birds.—(*Proc. Ind. Acad. Sci.*, **2**, No. 5).—Col. Froilano de Mello in collaboration with a number of his pupils has recently described 23 new species of *Hæmoproteus* from as many birds from Portuguese India. The descriptions are not accompanied by figures and the schizogony stages have not been observed in any case. The morphology of the gametocytes has been adequately described. In the genus *Hæmoproteus* only gametocytes occur in the red blood-corpuscles of peripheral blood, schizogony taking place in the endothelial cells of the blood-vessels of various internal organs, while in *Plasmodium* (*Proteosoma*) schizogony takes piace in the red blood-corpuscles and thus schizonts, merozoites and gametocytes can be found in them. Col. de Mello appears to have concluded that all the forms described by him are species of *Hæmoproteus* from not having come across schizogony stages in the peripheral blood. But it is not safe to do so. In the absence of definite knowledge about the occurrence of schizogony in the internal organs, we are left to judge from the morphology of the parasites themselves and their occurrence in relation to the nucleus of the infected corpuscle. In *Hæmoproteus* the organism is halter-shaped and grows round the nucleus without displacing it, while in *Plasmodium* (*Proteosoma*) the nucleus is ordinarily pushed to one side by the invading organism. Judged by this criterion as many as 14 out of the 23 species described would seem to belong to the genus *Plasmodium*, though in several of these the gametocytes are said to be halter-shaped. The systematic position of these species must consequently be regarded as *sub judice*.

B. L. B.

Coccidia of Lizards.—Dr. Setna reported a new Coccidium from the gall-bladder of the common lizard, *Hemidactylus flaviviridis* discovered by Miss R. H. Bana at Bombay (*Current Science*, 1933, p. 97). Col. R. Knowles and Dr. B. M. Das Gupta described the oöcysts of three species of *Eimeria* from the same host at Calcutta (*Ind. Journ. Med. Res.*, 1935, **22**) and designated them as species A, B, C. Discussing the previous literature, they thought that their 'species A' might correspond to *Eimeria raillieti* Léger, 1898, from *Anguis fragilis*, but were not able to secure the orginal paper in India, nor could it be ' unearthed in London '. The writer of this note has found out that this inability to unearth the paper is due to the reference having been wrongly cited by Wenyon (1926) as *Ann. Mus. Hist. Nat. Marseilles* instead of *Bull. Mus. Marseilles*, I, pp. 71–123. This latter is not available in India, but a description of the species was given by Léger (1899) in *C. R. Soc. Biol.*, (xi), I, pp. 309-311, and an abstract is available in *Wiegmann's Archiv* (1904, pt. 3, 115). I have carefully compared this with Knowles and Das Gupta's description of their 'species A', and find that the oöcysts correspond to those of *E. raillieti* in size, but those of the latter are oval and show a small button-like protruberance at one pole. I am therefore naming it elsewhere as *E. knowlesii*,

Their 'species B' is identical with Setna and Bana's *E. flaviviridis*, a full description of which has been published in *Journ. Roy. Micros. Soc.*, 1935, **55**, 256–260, and fully illustrated with diagrams of all the stages. The species shows a very close resemblance to *E. agamæ* Laveran and Pettit, 1910, as regards the occurrence of both schizogony and sporogony in the gall-bladder and bile ducts, and in the form and dimensions of the oöcysts, but differs as regards the form of the sporocysts. The latter are fusiform in *E. agamæ* and ovoid in *E. flaviviridis*.

Knowles and Das Gupta have already named their 'species C' as *E. hemidactyli*.

B. L. B.

The Kinetochore or Spindle Fibre Locus in Amphiuma.—The structure and significance of the Kinetochore are discussed in a paper by Franz Schrader (*Biol. Bull.*, June 1936, **70**, No. 3, 484). The term kinetochore was first applied by Sharp for a special region in the chromosome to which the spindle fibre is attached. It serves as a "chromosomal base for the connection between the chromosome and the pole". It consists of a deeply staining chromatoid body, lodged in an achromatic pit. Each tetrad in meiosis has two achromatic pits with two spherules each, while in the second spermatocyte, each dyad has two kinetochores with a spindle spherule in each. Staining reactions show that the kinetochore is quite distinct from an ordinary chromomere.

Fresh-Water Medusae from China.—Interesting experiments on Fresh-Water medusæ of the genus *Craspedacusta* occurring in a pond in Amoy, South China, are recorded in a paper by D. S. Tang, P. F. Yang and T. C. Fang (*Lingnan Sci. Journ.*, July 1936, **15**, No. 3, p. 445). Probably allied to *C. kawaii* and *C. sowerbii*, the medusæ were found in association with Potamogeton, the only flowering plant found in the pond. The animals were found to injest Cyclops and Volvox. They were extremely sensitive to temperature changes, even slight departures for 28° C. affecting their movements adversely. So also were changes in salinity and pH of the medium found to have adverse effects on them. The animals were seen to react towards light also in the same manner.

SCIENCE NOTES.

Surface Tensions by Bubble-Counting.—Messrs. R. N. Das and H. C. Bhuyan, Cotton College Laboratory, Gauhati, write :—

A new but comparatively simple method of measuring relative surface tensions of liquids has been developed in our Laboratory. The same volume of air is forced through a jet immersed successively in the two liquids to be compared and the numbers of bubbles escaping are counted in each case. If n_1 and T_1 represent the number of bubbles and the surface tension respectively of the first liquid and n_2, T_2 those of the second it has been found that the relation $n_1T_1 = n_2T_2$ holds good. Some ten organic liquids have been tried using water as the standard and the surface tensions so found have agreed with the standard values to within 2%. Exact agreement need not however be expected as the standard values given in tables of physical constants are obtained by different methods which vary amongst themselves by about the above range and in our case the measured surface tensions will be dependent on the value chosen for water. The air forcing device was a sort of manometric arrangement where the limb connected to the jet had three bulbs and the bubbles were counted only during the time in which the air of the middle bulb was being forced out. Varying the depth of the jet from 2 to 6 cm., the number of bubbles was found to be independent of the depth of immersion but it is a complicated function of not only the jet diameter but also of the shape of the tapering portion of the jet. A drawn-out glass tube was broken with a fine cut to obtain two jets of identical orifice but differing in the shape of the tapering portion just above the jet-mouth. Other conditions being alike, the two jets showed a difference in the number of bubbles with the same liquid. But it is remarkable that with either of them we obtained the correct values for surface tensions for the whole series of substances investigated. To test the method for small variations we measured the surface tensions of NaCl solutions at various concentrations and the slope of the tension-concentration curve came out to be exactly 1.53.

The method is interesting in that it requires very simple apparatus and makes the least demand on the time and skill of the observer. It will be found specially useful where surface tension measurements are involved as routine work.

* * *

Crab-Fishing in the Ceded Districts.—Mr. A. Ramakrishna Reddy, B.Sc. (Hons.), Annamalai University, Annamalainagar, writes :—

Paratelphusa (*Oziotelphusa*) *hydrodromus* (Herbst)[1] is the commonest edible crab of the Ceded Districts. It is fished on a small scale by the poorer classes for domestic use; but not for commercial exploitation. Its flesh is greatly relished and during the months of March, April, May and June, it is fished very extensively.

The species lives in deep burrows which have a peculiarly oblique descent on the muddy banks of ponds and small canals.[2] Often the crab is covered by patches of muddy colour characteristic of its environment. At one's approach it crawls back into its burrow with great rapidity.

Krauss[3] describes that in Natal *Scylla serrata* (Fôrskal) is captured by spear throwing. Sunder

[1] *Scylla serrata* (Fôrskal and *Varuna litterata* (Faber) are the commonest edible crabs of Lower Bengal. See S. L. Hora, *Proc. Zool. Soc. London*, 1933, 881–884.

[2] Compare the habits of *Scylla serrata*. See S.L. Hora, *Curr. Sci.*, 1933, **1**, 881.

[3] *A History of Crustacea* by Stebbing, p. 69.

Lal Hora[4] describes an implement consisting of a bent ironhook lashed into a split bamboo which is used for capturing *Scylla serrata* at Uttarbhag, Lower Bengal. In Ceded Districts the methods of fishing are somewhat different and in a way more efficient. A fairly long tough stick with a swollen node at one end is taken and fitted into a hollow suitable bamboo so that the bamboo barrel can be easily moved up and down this stick. The node at the lower end prevents the bamboo barrel from slipping down. If the node is not sufficiently big to prevent this slipping it is reinforced by winding a rope around it (Fig. 1).

For capturing the crab, this implement is passed down the hole and when the crab catches hold of the lower end by means of its powerful claws the bamboo barrel is pushed down and pressed hard against its chelæ. Subsequently without releasing the pressure exerted by the bamboo barrel the crab is pulled out. When legs other than the great chelæ are caught under the bamboo barrel the crab readily casts them off and escapes. But if the chelæ are trapped, it is not so easy for the crab to break them off. Of course, in a very few cases it does succeed to break off even the great chelæ, in its frantic efforts for freedom. In many cases, however, the barrel falls over a part or the whole of the body of the crab so that escape of the crab is rendered impossible. By this device the crab when once it catches hold of the stick is prevented from escaping during the process of being pulled out, by the action of the bamboo barrel. Further the crabs in many cases are captured unmutilated. Their powerful claws are, however, broken as soon as they are captured.

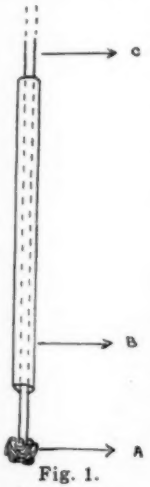

Fig. 1.

A. Swollen node.
B. Bamboo barrel.
C. A portion of the tough stick.

In shallow water when young ones of *Paratelphusa* are present in large crowds, circular nets are used for fishing them. They are captured in large quantities along with small fishes. During the hot months when the pools and ponds begin to dry up these crabs collect in large numbers in wet places towards the centre and are very easily fished out by the hand. The real fishing season for crabs in Lower Bengal according to Sunder Lal Hora,[5] is during the months of May and June, but in those parts the crab fishing extends over the months of March, April and May.

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[4] S. L. Hora, "Crab Fishing at Uttarbhag, Lower Bengal," *Curr. Sci.*, 1935, **3**, 543.

[5] S. L. Hora, *Jour. Proc. As. Soc. Bengal* (N. S.), 1932-33, **28**, 197-205.

Facts about the Sugar Industry of Australia.—Some important features of sugarcane cultivation and sugar manufacture in Australia observed by T. S. Venkataraman, the Government Sugarcane Expert, in the course of his recent visit to that country are described by him in *Livestock and Agriculture in India*, **6**, Part 3. Attention may be drawn to the following: The cultivation has been extensively mechanised with the result that one farmer with the help of only four labourers could produce 5,000 tons of cane (we are not told how many acres this represents, it is probably not less than some 50 acres); many a mechanical device was due to the ingenuity of the farmers themselves, being later improved and perfected by the manufacturer. Under irrigation, yields go up to 7 tons of sugar per acre, though for the country as a whole it is only about 2½ tons. Ratooning is general and cane is cut very low to induce growth from buds well below the surface, this having been found most favourable for ratoon-cane. Cultivation is practically on the level, there being no earthing up of cane at all; irrigation is probably by mere flooding, though this is not definitely stated. Badila (called in India by the name of Fiji B) is the variety of cane grown mainly. A point of great interest is the use of molasses as manure for cane, the stuff being applied directly to the land at the rate of 5 to 8 tons per acre and cane planted within a month after the application; we should have a reference made to a curious case of molasses ridding a field of a pest of worms, making a 40 ton crop possible where previously it was difficult to grow any cane. This is a subject well worth going into further. Labour on the cane fields is paid at 8 16 (or about Rs. 9) per day. In fighting diseases, importance is attached mainly to the raising of resistant varieties but the significant remark is made that susceptibility is often a question of environment. Methods of disease and pest control are very thorough, these being strengthened by adequate legislation. Steeping of cane setts in hot water at 52° C., correcting the acidity of solid varietal rotation have been important cultural methods of disease control. The control of pests by parasites, checking the white-ant pest with arsenic-soaked saw dust buried in the soil and the "grey bark beetle" by the giant toad, *Bufo Marinus*, are other interesting items of information. The spread of the Co. canes in that country notably the Co. 291 was noteworthy; it had yielded up to 50 tons of cane per acre. We wish this interesting note was more detailed.

* * *

Improvement of Crops in India.—A press note recently issued by the Director of Public Information gives a review of the research activities relating to the improvement of crops, carried out under the auspices of the Imperial Council of Agricultural Research.

The area under improved varieties of crops is now over 16,000,000 acres, representing an increase of over 20 per cent. in the course of the last two years. The corresponding area in the States rose by 12 per cent. last year. These figures are certainly an underestimate as it is

impossible to ascertain the full extent of the natural spread of improved varieties, once they become popular.

The progress of work on the production of improved varieties of crops, carried out by the Provincial Agricultural Departments has been considerably accelerated through the assistance rendered by the Imperial Council of Agricultural Research. The Council's responsibility extends only to the encouragement and co-ordination of the work of the Provincial Agricultural Departments and the dissemination of scientific information.

Improvement of crops consists in evolving varieties having superior quality, heavier yielding capacity, disease resistance and better adaptability to environment. The variety selected usually combines several of these factors.

A good many crops have come under the purview of the Imperial Council, rice, wheat, sugarcane, cotton, tobacco, etc. Research stations for improving rice have been established in Madras, Bengal, Bihar, United Provinces, Central Presidency and Burma. Strains suitable for cultivation in the various provinces have been evolved. To mention an instance, the Madras variety known as *G. E. B.* 24, which has proved a great success, is distributed to the extent of over 300 tons of rice seed per season in the Madras Presidency by the Agricultural Department, while the seed farms under departmental supervision provide seed for 300,000 acres or more. The researches conducted at Pusa and Lyallpur on wheat have resulted in bringing a sixth of the total area under improved varieties. The variety known as Cross 518 has been found to be ideal for rich soils, while for '*barani*' (un-irrigated) conditions, the variety known as *9D* has given good results. Investigations on rust-resistant strains are being conducted under the auspices of the Council. Remarkable progress has been made with respect to the cultivation of sugarcane. Over 70 per cent. of the area is now under improved varieties. The results achieved by the researches at the Coimbatore Station are widely known. The latest development is the successful production of Jowar—sugarcane hybrids. The Council has recently decided to finance research on the insect pests of sugarcane and the work will be carried out at the Imperial Institute of Agricultural Research, New Delhi. On the technological side, the Central Imperial Institute of Sugar Technology has been established in Cawnpore, for the training of technical staff for sugar factories. Regarding tobacco, another important money crop, the researches carried out at Pusa have resulted in the successful production of hybrids between American and Indian varieties, suitable for cigarette manufacture. Over 2,500 flue-curing barns have been established all over India, mainly in the Guntur District and a special tobacco research station will soon be founded for the study of quality of tobacco. A remarkable expansion in fruit industry has recently been witnessed. Successful storage and transport experiments have been made in Bombay on mangoes and oranges, and a grant has been made to Baluchistan for an experimental fruit canning plant.

The researches on crops originated by the Imperial Council of Agricultural Research extends beyond the mere evolution of crops. The work includes researches on soils, crop pests, plant diseases, soil management, agricultural meteorology and production of efficient implements useful in agricultural practice.

* * *

Recent Researches at the Institute of Agricultural Research.—An efficient and simple method has been evolved by the Imperial Institute of Agricultural Research for the manufacture of clean and attractive coloured *gur* and for the manufacture of white sugar by the open method which will be within the means of the sugarcane grower (Press note from the Director of Public Information, Simla). The method and the equipment are so flexible that the ryot can manufacture good quality *gur* or sugar according to the needs of the market. It is said that this new method which is not a competitor to factory production, has a promising future and is destined to play its rôle in the future of sugar industry of India.

The Institute has also succeeded in developing starter cultures which are an improvement in practical dairying for producing rich flavour and aroma in butter. These have been tested in a laboratory and are used on a large scale in Bangalore Dairy with very satisfactory results.

A simple method for the cheap production, from locally available materials, of what is well known as *E. C.*, a chlorine disinfectant, has been developed and perfected. It is said that this is now being used extensively as disinfectant in hospitals, railways, sugar factories, and a number of other places.

* * *

Indian Central Cotton Committee.—An important matter reported at the 32nd meting of the Indian Central Cotton Committee, held on the 13th and 14th January 1936, is the securing of a larger market for Indian cotton in the U. K. Thanks to the endeavours of the Lancashire-Indian Cotton Committee; a more intensive propaganda to the same end is also foreshadowed. The discussions relating to the trade in cotton centred round legislation for checking malpractices, by amendments to the Cotton Ginning and Pressing Act, by the regulation and control of Cotton Options and the zoning of areas for particular varieties of cotton. Some very flagrant cases were referred to, one especially of cotton having been watered to the extent of 20 per cent. in one of the godowns! In regard to cotton research which the Committee has been financing we are glad to note that the various grants are all to be continued even though this entails the drawing from the Committee's reserves to the extent of Rs. 3 lakhs. The discovery by the Cotton Physiologist of an organism in the tissues of the cotton plant which he was inclined to claim as a causal organism for the well-known maladies of American Cotton grown in this country and which aroused considerable interest at the time was decided to be put to further scrutiny. The Technological Institute has taken up the investigation of the cellulose content of different cottons, the objective being their industrial utilisation for the making of artificial silk;

we are particularly gratified at this widening of the scope of the Institute; it happens to be a step we have strongly urged. A rather exciting discussion over certain criticisms of the work and policy of the Committee made in England by Sir Albert Howard who put the Committee on its mettle was a feature of the meeting. The Committee naturally joined issue in a spirited manner and one cannot help thinking that Sir Albert's criticism was quite unjustified. One may concede much to the claims made for the Indore process of compost-making without subscribing to his view that the Cotton Committee should popularise it far and wide and that the expenditure on cotton pest investigations and seed distribution schemes is a waste of money. Such a view to our mind shows a wrong understanding of the requirements of the situation and of the scope of this Committee *vis-à-vis* the regular Agricultural Departments. Thanks to the efficient publicity service of the Committee, a resumé of these proceedings has already appeared in the press.

* * *

The National Geographic Society.—Dr. Irvine C. Gardner, American scientist, who under the auspices of the National Geographic Society and the National Bureau of Standards, led an expedition to U. S. S. R. to study the total eclipse of the sun on June 19, recently returned to America with 8 large pictures of the recent total eclipse of the sun and its corona. The photographs are believed to compare favourably with the best photographs made during the previous eclipses.

Dr. Gardner, accompanied by his wife who is also a scientist, made the photographs at Ak Bulak, U. S. S. R., on June 19, with a huge camera equipped with a lens system which he had invented for the purpose.

Dr. Gardner obtained both black-and-white and natural colour photographs of the sun's corona or halo with exposures ranging from 1 to 16 seconds. As a result of frequent rehearsals Dr. and Mrs. Gardner were able to utilise 56 of the 117 seconds of the total eclipse in actually making exposures, requiring 61 seconds for the changing of plate holders, and the removal and replacement of dark slides.

Dr. Gardner developed his valuable films and plates at Ak Bulak and brought them by hand to the United States. There has been no time so far for the detailed study of the images, but he expressed himself as highly pleased with the apparent results. Even the 1-second exposures show the corona extending hundreds of thousands of miles outward from the disk of the sun; while the 16-second exposures show some streaks of light in the corona extending from the disk more than 1¾ times the sun's diameter. These pearly pencils of light are probably well over a million miles in length.

All of the photographs show apparent nicks in the edge of the sun's disk. These were caused by extreme brilliance of the 'prominence'—intensely hot flames which lick out from the sun's surface for perhaps thousands of miles. These flames are believed to be ignited hydrogen gas.

* * *

Blood Parasites of the Indian Birds.—At the ordinary monthly meeting of the Royal Asiatic Society of Bengal, held on Monday the 7th September, Col. I. Froilano de Mello gave a paper bearing on his contributions to the study of Blood Parasites of the Indian Birds. Col. De Mello gave a complete list of the Hemoparasites recorded from Indian birds, and discussed their classification and relationship. In addition, he described a number of species of Hæmoproteids which he has studied in detail from Nova Gôa and other places.

The following were balloted for as ordinary members:—(1) The Hon'ble Sir Bijay Prasad Singh Roy, Kt., (2) Jadunath Sinha, M.A., Ph.D., (3) Daulat Ram, (4) Rai Bahadur Kumar Nath Bagchi, B.Sc., M.B. (Cal.), D.T.M. (Cal. and L'pool), F.I.C. (Lond.), and (5) N. T. Williams.

* * *

At the third ordinary meeting of the **Indian Chemical Society**, held on Friday the 28th of August 1936, at 5 P.M. in the Chemistry Lecture Theatre, University College of Science, 92, Upper Circular Road, Calcutta, with Prof. Dr. B. B. Dey in the Chair, the following gentlemen were admitted as Fellows, their subscriptions having been received for the first time:

G. P. Pendse, Esq., M.Sc. (Gwalior); Dr. Surendra Nath Ray, M.Sc., Ph.D. (Calcutta); Kalipatnapu Kondaiah, Esq., M.Sc. (Benares); S. Raju, Esq., M.Sc. (Benares); Prof. Satyendra Nath Bose, M.A. (Dacca); Dr. Lavji Thoria, Dr. Ing. (Bombay); Akundi Jogarao, Esq., M.Sc. (Benares); Sarju Prasad, Esq., M.A., M.Sc. (Benares); G. R. Phansalkar, Esq., M.Sc. (Benares); Dhirendra Nath Majumdar, Esq., M.Sc., A.I.I.Sc. (Benares).

The following gentlemen were elected as Fellows by ballot, Dr. K. N. Bagchi and Dr. P. C. Mitter acting as scrutators:

Gyanendra Nath Banerjee, Esq. (Bombay); Mahadeo Ganesh Kale, Esq., M.A. (Bombay); Nirmalendu Nath Ray, Esq., M.Sc. (Rajshahi); Nadiabehari Adhikari, Esq., M.Sc. (Calcutta); H. Ramaswamy Iyengar, Esq. (Mysore); S. Venkata Rao, Esq., M.Sc. (Bangalore); Dr. K. S. Nargund, M.Sc., Ph.D. (Ahmedabad); P. D. Swami, Esq., B.Sc. Visharad, (Benares); Dr. Pulin Behari Sarkar, D.Sc. (Calcutta); Baradananda Chatterjee, Esq., M.Sc. (Calcutta); Narayan Chandra Sen-Gupta, Esq. (Calcutta).

Prof. Dr. J. C. Ghosh delivered a lecture on "Recent Work on the Oxidation-Reduction Potential of Systems of Biological Interest". Dr. B. B. Dey, Dr. B. C. Guha and Dr. J. N. Mukherjee took part in the discussion.

* * *

The Principal Rots of English Oak.—(His Majesty's Stationery Office. Price 2*s.* net. Post Free 2*s.* 3*d.*)—"The Principal Rots of English Oak" provides a concise survey of existing knowledge and of recent work carried out at the Forest Products Research Laboratory on the subject of decay in this timber. Adequate keys and descriptions are given which facilitate the recognition of the different rots and fungi concerned. These together with information on the economic aspects of the various rots, and in

some cases on control measures, as well as physiological and cultural data, make this handbook a very useful work of reference both to those who handle or use the timber on a large scale and to students of forestry and botany.

* * *

It is learnt that the Royal Society, London, have approved plans for medical research on malaria and nutrition in India. It is estimated that the total expenditure for the next five years amounts to £8,000. Col. Sinton will investigate certain aspects of malaria with the help of the London School of Hygiene and Tropical Medicine; a study of mosquitoes in the tropics will be made. Dr. C. Wilson will undertake a survey of nutritional conditions in India.

* * *

A prize of Rs. 100 (announced by the *Indian Journal of Venereal Diseases*) was awarded to Dr. D. V. Subba Reddi, M.B.B.S., Medical Registrar, Medical College, Vizagapatam, for the best original thesis on 'Antiquity of Syphilis (Venereal Diseases) in India'. The thesis was judged by a committee consisting of: Lt.-Col. K. K. Chattarjee, Dr. R. V. Rajam, Lt.-Col. Jelal M. Shah, Dr. P. V. Gharpure and Dr. U. B. Narayanrao. The thesis is now printed in a book form and can be obtained from the Office of the Indian Journal of Venereal Diseases.

* * *

Dr. Harendranath Ray, M.Sc., Ph.D., postgraduate lecturer in Zoology, University of Calcutta, has been appointed Protozoologist, Imperial Institute of Veterinary Research, Muktesar.

* * *

Flexible High Vacuum Seals.—In the studies involving high vacuum technique, tight, non-gassing connections are necessary between the pump and the gauge or between the pump and the system being exhausted, which could be quickly made and quickly removed. The use of glass seals is out of question because of the frequency with which they have to be made and broken. Further the connection to the pump is always a glass to metal connection. Recently this problem has been solved by a new preparation called the *Cenco Seal*. The seal can be applied to metal-to-metal, metal-to-glass, or glass-to-glass joints. It requires that the outside diameters of the connecting tubes be about equal, and that their ends be cut off reasonably 'square'. The two tubes are brought in abutment. The joint between them is surrounded by a strip of thin metal, like aluminium, closely fitting but ends not overlapping. The purpose of this collar is two-fold—to prevent exposure of rubber surface to the vacuum and to prevent atmospheric pressure from causing intrusion of the rubber into the system. Several strips of the cohesive rubber tape are then wrapped around the joint, for a distance of a few centimetres on each side of the collar. The tape thus wrapped forms a homogeneous sleeve of soft rubber about the joint, which perfectly seals it. If the joint is to be semi-permanent, a coating of shellac may be applied over the rubber. To 'take down' a Cenco Seal, the rubber is cut with a safety razor blade.

The tape is supplied by Central Scientific Co., 460, East Ohio Street, Chicago, in strips separated by non-sticking sheets. Once its surfaces are pressed together, they cohere and cannot be separated.

* * *

The discovery that *ephebogenesis*—reproduction with only male cells present—is perfectly possible in nature has recently been demonstrated by Dr. E. Newton Harvey, Princeton biologist. Parts of the eggs of sea urchins which contained no female nuclei were found to be capable of development by whirling into living organisms in a new centrifuge microscope developed in the laboratories of *Bausch & Lomb Optical Co.*

This "cell carrousel" is a streamlined rotor mounted on the shaft of a fast electric motor. Inside the rotor an ingenious system of microscope optics and prisms has been built to reflect light up into the eyepiece. At 10,000 revolutions per minute the light impulses reaching the eye are of the order of 1/300,000 of one second, but repeated 10,000 times a minute the impulses give the impression of a continuous image.

The force developed by this centrifuge is 12,000 times gravity. As the cell is whirled, the molecular particles are separated according to their specific gravity.

The action on the cell results in an acceleration of the process of sedimentation. While the principle of the centrifuge is not new, a microscope connected with it to observe the specimen and for recording the process of disintegration photographically is of the greatest interest to biologists and physiologists. Dr. Harvey, in his experiments on the egg of the sea urchin, *Arbacia*, has shown how the cell stretches and ultimately divides into halves, each half having life.

The molecular weight of extremely minute particles may be determined by measuring the speed at which they travel through a fluid for a known centrifugal force. The minute unicellular organism, *Paramecium*, may be weighed by finding the exact point at which it fails to swim against a definite centrifugal force. This tiny organism, 0.25 mm. long, with a weight of 0.000175 mg., can lift nine times its own weight.

Many processes of industry and puzzles of medicine and biology are at present hidden in the still unknown structure of the cell and of the large protein molecules, such as those of silk, rubber, rayon and wood.

A demonstration of the Harvey-Loomis centrifuge microscope was recently given before a distinguished group of scientists on July 20, at the opening of Bausch & Lomb's new offices, 35th Floor, R. C. A. Building, Rockfeller Center, New York City.

* * *

Announcements.

Indian Science Congress Association.—It has been proposed that discussions and symposia on the following subjects may be arranged at the next Session of the Indian Science Congress Association to be held at Hyderabad in January, 1937, provided the proposal receives sufficient support. Members of the Science Congress interested in the proposal

are hereby requested to get into touch with the Sectional President whose name is mentioned against the subject for discussion in the following list :—

I. "On Wegener's Theory of Continental Drift as regards India and Adjacent Countries." (Joint Discussion—Geology and Geography, Zoology and Botany Sections.)
Mr. W. D. West, M.A., Geological Survey of India, 27, Chowringhee, Calcutta.

II. "On the Need for a Soil Survey for India." (Joint Discussion—Geology and Geography and Agriculture Sections.)
Mr. W. D. West, M.A., Geological Survey of India, 27, Chowringhee, Calcutta.

III. "The Age of the Deccan Trap." (Geology and Geography Section.)
Mr. W. D. West, M.A., Geological Survey of India, 27, Chowringhee, Calcutta.

IV. "On Nutrition in Relation to Crops as well as Human Beings and Farm Livestock." (Joint Discussion—Medical and Veterinary Research, Physiology, Agriculture and Chemistry Sections.)
Col. A. Olver, F.R.C.V.S., Animal Husbandry Expert, Imperial Council of Agriculture Research, New Delhi.

* * *

Indian Journal of Venereal Diseases.—*Award of Prizes* :—Two prizes, each of the value of Rs. 100, will be awarded for articles on the subjects mentioned below :—

1. 'Serology in the diagnosis and prognosis of Venereal diseases'.
2. 'Investigations into lymphogranuloma inguinale'.

These prizes have been offered to the Journal, the first by the Manwantar Printing Press and the second by an esteemed 'Admirer' of the *Indian Journal of Venereal Diseases* who has preferred to remain anonymous, 'as an humble contribution towards the noble and selfless cause of carrying on an extensive and expensive propaganda by the Journal'. The two prizes are to be awarded to the best article in each of the announced subject.

* * *

The Second International Congress of the International Association for Testing Materials will be held in London in April, 1937, under the presidency of Sir William Bragg. Further information can be had from Mr. K. Headlam-Morley, 28, Victoria Street, London, S.W. 1.

* * *

Applications are invited from science graduates with M.R.C.V.S. diploma for the award of a research scholarship of Rs. 150 per month tenable for two years, for conducting research on a suitable subject in veterinary science at the Imperial Institute of Veterinary Research, Muktesar. The Inter-University Board, India, has recognised the Institute as a centre for post-graduate training leading to the degrees of PH.D. and D.Sc. of Indian Universities. Applications will be received by the Director, Imperial Institute of Veterinary Research, Muktesar, Kumaon P.O., U.P., up to the 12th October 1936.

* * *

Applications are invited for—(1) Medical Officer for Health, Gadag Belgiri Municipal Borough ; salary Rs. 200–20/2–300–20–400 ; apply to President, Gadag Belgiri Municipal Borough, Municipal Office, Gadag. (2) Spinning Master, Technological Research Laboratory, Matunga, Bombay ; salary Rs. 500 ; apply to Secretary, Indian Central Cotton Committee, P. O. Box 10,002, Bombay ; last date for application : 30th September 1936. (3) Lecturer in Physics, University College, Rangoon, from November 1, 1936 to March 15, 1937 ; salary Rs. 400 per month ; Apply to Principal, University College, Rangoon ; last date for application : October 15, 1936. (4) Registrar of the Bengal Council of Medical Registration and Secretary to State Medical Faculty, Bengal ; salary Rs 400–20–500 ; apply to President, Bengal Council of Medical Registration, 21, Old Court House Street, Calcutta ; last date for application : 30th September 1936. (5) Two posts as Superintendents of Farms, salary Rs. 150 to 250 according to qualifications ; apply to Economic Adviser, Bhopal.

* * *

We acknowledge with thanks receipt of the following :—

"The Agricultural Gazette of New South Wales," Vol. XLVII, No. 8, August 1936.

"Journal of Agricultural Research," Vol. 52, No. 12, and Index to Vol. 51.

"Indian Journal of Agricultural Science," Vol. VI, No. 3, June 1936.

"Monthly Bulletin of Agricultural Science and Practice," Vol. 27, No. 7, July 1936.

Dominion of Canada, Department of Agriculture :—Publication No. 478 : "Lamb Feeding in Southern Alberta with a Supplement on the Utilisation of the Forest Reserve for Summer Sheep Pasture" ; Pub. No. 483 : "The Potato in Canada" ; Pub. No. 487 : "Trends in the Canadian Tobacco Industry 1920–1934" ; Pub. No. 502 : "Skin Scabies or Mange of the Fox," by P. J. G. Plummer ; Pub. No. 505 : "Insects Attacking the Potato" ; Pub. No. 507 : "Package Bees and how to install them" ; Pub. No. 511 : "Goose Raising".

"Journal of Agriculture and Livestock in India," Vol. VI, Part IV, July 1936.

"The Philippine Agriculturist," Vol. XXIV, No. 3, August 1936.

"The Allahabad Farmer," Vol. X, No. 4, July 1936.

"Journal of the Royal Society of Arts," Vol. LXXXIV, Nos. 4365–4369.

"The Biochemical Journal," Vol. 30, Nos. 6 and 7, June and July 1936.

"Journal of the Indian Botanical Society," Vol. 15, No. 4, August 1936.

"Communication from the Boyce Thomson Institute," Vol. 8, No. 2, April-June 1936.

"Journal of the Institute of Brewing," Vol. XLII, No. 8, August 1936.

"The Calcutta Review," Vol. 60, No. 3, September 1936,

" Carnegie Institute of Washington—New Service Bulletins," Vol. IV, No. 6, " Important Maya Discovery in the Guatemalan Highlands".

" Chemical Age," Vol. 35, Nos. 890–894.

" Journal of Chemical Physics," Vol. 4, No. 8, August 1936.

" Journal of the Indian Chemical Society," Vol. 13, Nos. 6 and 7, June and July 1936, and Index to Vol. 12, 1935.

" Berichte der Deutschen Chemischen Gesellschaft," Vol. 69, No. 8.

" Transactions of the Faraday Society," Vol. 32, Part 8, August 1936.

" Indian Forester," Vol. LXII, No. 9, September 1936.

" Indian Forest Records," Vol. II, No. 3, Silviculture :—" A Stand Table for Chir (*Pinus longifolia*, Roxb.)."

Vol. I, No. 1, Silviculture : " A Preliminary Survey of the Forest types of India and Burma."

Vol. II, Nos. 2 and 3, Entomology : " Immature Stages of Indian Coleoptera (19) " ; " Entomological Investigations on the Spike-disease of Sandal."

Vol. II, No. 4, Entomology : " New Indian Cerambycidæ," by J. C. M. Gardner.

" Forschungen und Fortschritte," Vol. 12, Nos. 22–24.

Government of India Publications :—

" Monthly Statistics of Production of Certain Selected Industries of India " (Department of Commercial Intelligence and Statistics), Nos. 1 and 2 of 1936–37, April and May 1936.

Indian Meteorological Departments, Vol. VI, No. 68 : "Hourly Rainfall at Lahore," Vol. VII, No. 69, " A Statistical Analysis of the Distribution of the South-West Monsoon Rainfall at Akola".

"Indian Trade Journal," Vol. CXXII, Nos. 1573–1576.

"Memoirs of the Geological Survey of India," Vol. LXX, Part I. "An Attempt at the Correlation of the Ancient Schistose Formations of Peninsular India," by Sir L. L. Fermor, 1936.

" Quarterly Bulletin of the Health Organisation," Vol. V, No. 2, June 1936.

League of Nations—" The Problem of Nutrition : Vol. I, Interim Report of the Mixed Committee on the Problem of Nutrition," Vol. III, " Nutrition in Various Countries."

" Medico-Surgical Suggestions," Vol. 5, No. 7, July 1936.

" Mathematics Student," Vol. IV, No. 1, March 1936.

" The Micro," No. 4, July 1936. (Post Office Journal of Ceylon.)

" Geological, Mining and Metallurgical Society of India "—Annual Report for the Session 1935–36.

" Nature," Vol. 138, Nos. 3483–3485.

" Indian Journal of Physics and Proceedings of the Indian Association for the Cultivation of Science," Vol. X/(XIX), Part IV.

" Ceylon Journal of Science," Vol. IV, Part II, Medical Science ; Vol. XX, Part I, Zoology and Geology : *Spolia zylanica*" and Index to Vol. XIX.

" Science and Culture," Vol. II, No. 3, Sept. 1936, and Index to Vol. I.

" Science Forum," Vol. I, No. 6, August 1936.

" Lingnan Science Journal," Vol. 15, No. 3, July 1936.

" Indian Journal of Veterinary Science and Animal Husbandry," Vol. VI, Part II, June 1936.

Catalogues :

" Photo-Micrographic Equipment " (Messrs. Bausch and Lomb Optical Co., Rochester, N. Y.).

" Scientific and Technical Books," June 1936 (Messrs. Edward Arnold & Co.).

" Monthly List of Books on Natural History and Science," August 1936 (Messrs. Wheldon & Wesley, London).

ACADEMIES AND SOCIETIES.

Indian Academy of Sciences :

August 1936. SECTION A.—GURDAS RAM AND V. I. VAIDHIANATHAN : *Uplift Pressure and Design of Weirs with Two Sheet Piles.*—As the toe of a Weir is its vulnerable point, Weir design must commence from the downstream end, so as to control the exit gradient. T. R. SESHADRI AND P. SURYAPRAKASA RAO : *Geometrical Inversion in the Acids derived from the Coumarins. Part III.* Trans to Cis.—Heating with mercuric chloride in neutral aqueous solution has been found to be very satisfactory. T. R. SESHADRI AND P. SURYAPRAKASA RAO : *Reactivity of the Double Bond in Coumarins and Related α-β Unsaturated Carbonyl Compounds. Part II.—Reaction of Mercury Salts on Coumarins.*—It is established that mercuric acetate reacts with the double bond in the coumarins studied and further mercurates the benzene ring in positions 6 and 8 if they should be free. Mercuric chloride does not react with 6-nitro-coumarin. I. CHOWLA : *On Sums of Powers.* S. CHOWLA : *Note on Waring's Problem.* C. S. VENKATESWARAN : *Polarisation of Raman Lines in Some Inorganic Acids.*—Nitric, iodic, sulphuric, selenic and selenious acids have been investigated, and their structural formulas discussed in detail. S. RAMACHANDRA RAO : *Magnetism and Cold Working in Metals. Part II.—Single Crystals of Bismuth, Zinc and Tin.*—Single crystals of Bismuth, Zinc and Tin were prepared by the method of slow cooling and the influence of cold working on the principal susceptibilities was investigated. R. ANANTHAKRISHNAN : *The Raman Spectra of Tri-Methyl-Amine and Some Compounds of Hydroxylamine and Hydrazine.*—The proper assignment of the Raman lines and the constitution of the salts have been discussed in detail with aid of polarisation data. S. PARTHASARATHY : *Ultrasonic Velocities in Organic Liquids. Part VI.—Related Compounds.* H. GUPTA : *Decomposition into Cubes of Primes (II).* N. S. NAGENDRA NATH : *The Diffraction of Light by High Frequency Sound Waves : Generalised Theory. The Asymmetry of the Diffraction Phenomena at Oblique Incidence.*—A solution is attempted of the

difference-differential equation in Raman and Nath's papers IV and V. The idea of 'propagation' of light in a quasi-homogeneous medium is fundamental and preferable to the undefined idea 'reflection' in such a medium. P. K. RAMAN: *Studies in Atmospheric Radiation. A Discussion of Some Observations of Nocturnal Radiation made at Poona and Sinhagad.*

August 1936. SECTION B.—T. R. BHASKARAN: *Studies on the Mechanism of Biological Nitrogen Fixation. Part III.—Economy of Carbon during Fixation of Nitrogen by* Azotobacter chroococcum *Beij.*—The mechanism of nitrogen fixation in soil is different from that by Azotobacter alone in pure cultures. BAHADUR SINGH: *The Life-History of* Ranunculus sceleratus *Linn.*—The morphology of *Ranunculus sceleratus*, the most primitive species of the genus, has been reported. MAKUND BEHARI LAL: *A New Species of the Genus* Levinseniella *from the Jack Snipe,* Gallinago gallinula. M. S. RANDHAWA: *Contributions to Our Knowledge of the Freshwater Algæ of Northern India. I.—Oedogoniales.* JEHANGIR FARDUNJI DASTUR: *A Nematode Disease of Rice in the Central Provinces.*—A new disease caused by a nematode of the genus *Aphelenchoides* is described. C. R. HARIHARA IYER AND R. RAJAGOPALAN: *Estimation of Nitrogen by Fumeless Digestion. Part III.—Extension of Chromo-Sulphuric Acid Digestion to include Large Quantities of Nitrates.* B. M. JOHRI: *Studies in the Family Alismaceæ IV.* Alisma plantago *L.*; Alisma plantago-aquatica *L. and* Sagittaria graminæ *Mich.*—An account of the embryo sac of 3 plants of the family Alismaceæ is given. B. M. JOHRI: *The Life-History of* Butomopsis lanceolata *Kunth.*—From the embryological point of view, there is a close affinity between the *Alismaceæ* and *Butomaceæ* and their separation into two different orders is unnecessary. T. R. BHASKARAN AND V. SUBRAHMANYAN: *Studies on the Mechanism of Biological Nitrogen Fixation. Part IV.—Nitrogen Fixation by the Mixed Microflora of the Soil in Presence of the Acid Products of Anærobic Decomposition of Carbohydrates.* NUGGEHALLI KESHAV IYENGAR AND MOTNAHALLI SREENIVASAYA: *Studies on Inulinase.*—Highly active preparations of inulinase can be obtained from a species of *aspergillus* grown on artichoke nutrient media. A definite relationship exists between the phosphorus content of the preparation and its inulinase activity.

Indian Chemical Society:

June 1936.—O. N. KUMARASWAMY AND B.L. MANJUNATH: *Chemical Examination of the Fixed Oil from the Seeds of* Celastrus Paniculatus, *Willd.* B. C. SHAH AND P. R. MEHTA: *C-Alkyl Resorcinols. Part II.—Synthesis of Poly-Alkyl Resorcinols.* JNANENDRA NATH MUKHERJEE, SUBODH GOBINDA CHAUDHURY AND KRISHNADHAN BHABAK: *Variation of the Cataphoretic Velocity of Colloidal Particles during Aggregation—Part I.* B. B. DEY, S. RENGACHARI AND M. V. SITHARAMAN: *Peroxidases. Part III.—A Potentiometric Method of Estimating their Activity.* PANCHANAN NEOGI AND SARAJIT KUMAR NANDI: *New Compounds of Gallium—Part I.* K. V. BOKIL: *Oxidation of Acetyltetrahydroquinoline Sulphonic Acids.* SATYAPRASAD ROY-CHOUDHURY, SARAJIT KUMAR NANDI AND JIBAN KRISHNA BANERJEE: *On Activated Charcoal. Part II.—Purification by Washing with Water and by Activation.* S. K. RANGANATHAN: *A Synthesis of* cis- *and* trans-dl-iso *Propylcyclopropane-1 : 2-dicarboxylic acid and experiments towards the Resolution of* cis-dl-*acid.*

July 1936.—P. C. RAY AND ANIL CHANDRA RAY: *On the fluorination of organic compounds. Part II.* JNANENDRA NATH MUKHERJEE, SUBODH GOBINDA CHAUDHURY AND JYOTIRMOY SEN-GUPTA: *Variation of cataphoretic velocity of Colloidal particles during Aggregation.* SHRIDHAR SARVOTTAM, JOSHI AND SADASHIV S. KULKARNI: *Studies in the coagulation of colloids. Part XIV. Coagulation of colloid arsenious sulphide by mercuric chloride. Inadmissibility of viscosity and transparency as general criteria of coagulation.* P. C. MITTER AND (MISS) TANIMA SEN-GUPTA: *Studies in the Anthraquinone Series—Attempts to synthesise anthraquinone carboxylic acids of the Morindone type.* B. N. GHOSH: *The Enzymes in Snake venom. Part I.—Their Action on Hæmoglobin and on Protein Solutions of Different pH.* SUSIL KUMAR RAY AND RAMA RANJAN BHATTACHARYA: *On the Study of Polyhalides. Part IV.—Formation and Dissociation of Polyhalides of Ammonium and Substituted Ammonium Bases.* M. GOSWAMI AND A. SHAHA: *Attempts to prepare ring glycerides. Preparation of tetrachlorodiglycerides of dicarboxylic acids.* MOHAN SINGH: *The rotatory powers of substituted camphoranilic acids.* NARSHINH MULJIBHAI SHAH AND RUPCHAND LILARAM ALIMCHANDANI: *Chloral Derivatives of Salicylic Acid.* NARINDRA NATH CHOPRA AND JNANENDRA NATH RAY: *Methoxy-oxypalmatine.* ANUKUL CHANDRA SIRCAR AND SAILESH CHANDRA SEN: *Studies in the Acenaphthene quinone series. Part II.* SUSIL KUMAR RAY: *Parachor and the structure of formic acid.* SACHINDRA NATH ROY: *A Note on the use of adsorption indicators in acidimetry and alkalimetry.*

Indian Botanical Society:

August 1936.—S. K. PANDE: *Studies in Indian Liverworts :—A Review.* L. P. KHANNA: *On Indian Species of the Genus* Anthoceros *Linn. with a Description of a New Species from Travancore.* P. PARIJA AND K. SAMAL: *Extra-Floral Nectaries in* Tecoma capensis *Lindl.* S. C. VARMA: *Some Ecological Aspects of the Upper Gangetic Flora.*

Calcutta Mathematical Society:

August 16, 1936.—N. N. GHOSH: *On a Class of Determinants having Geometrical Applications.* A. C. CHOWDHURY: *On Reducible Hyperelliptic Integrals.* C. N. SRINIVASIENGAR: *Lines of Striction on the Quadric and on Some Other Scrolls.* S. GHOSH: *Plain Strain in an Infinite Plate with an Elliptic Hole.* M. DE DUFFAHEL: *On a Class of Integral Equations.* A. MÖESSNER: *Simultane Identitaten.*

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Benares Hindu University:

The Inaugural Address of the Scientific Society was delivered on the 6th September by Professor B. Sahni of Lucknow University. The subject of the address was "Early Man in Northern India."

Professor Sahni has been appointed an Honorary Professor of the Benares Hindu University.

Calcutta University:*

Personnel.—Mr. Syamaprasad Mookerjee has been re-appointed Vice-Chancellor of the University.

Mr. A. Macdonald, Principal, Bengal Engineering College, retired from service after a distinguished career in the Education Department, extending over 25 years.

Grants.—The Imperial Council of Agricultural Research has sanctioned a scheme for the investigation of the life-history, bionomics and development of freshwater fishes of Bengal. The investigation will be carried out under the direction of Prof. H. K. Mookerjee, Professor of Zoology. A grant of Rs. 6,620, extending over a period of 3 years has been provided by the Imperial Council and this is to be supplemented by a non-recurring grant from the Calcutta University.

Courses of Study.—The committee appointed by the Syndicate to consider the question of the inclusion of the pre-medical course for the M.B. Examination in the syllabus for the I.Sc. examination has submitted its report to the Syndicate recommending that the pre-medical course comprised in the preliminary science M.B. examination, be included in a special I.Sc. course to be instituted for the purpose. If the report is adopted, students passing the special I.Sc. examination will be entitled to begin their studies from the second year class of the Medical College and finish their medical course within five years.

Awards.—Mr. Subhendusekhar Basu (Thesis: 'Theory of distribution in statistics and its application') and Mr. Nalinikanta Saha (Theses: 'Studies in the electrical theory of solid metal'; 'On the pressure of electrical resistance in metals') have been elected to the Premchand Roychand studentship in scientific subjects from July 1935.

Srimati Kamala Debi, of the Vidyasagar College, Calcutta, has been awarded the Basanta Gold Medal for 1935, for her thesis on 'Health Education through Schools in Bengal'.

Dr. Sukumar Sarkar, D.Sc., has been awarded the Sir Asutosh Mookerjee Medal for 1935, for his thesis entitled 'The Nature of solid and liquid as revealed by light scattering".

*With acknowledgments to the "Calcutta Review," September, 1936.

University of Madras:

Mr. R. Littlehailes, Vice-Chancellor, who was on leave from the 5th June, returned on Saturday, the 29th August, and joined duty the same day (afternoon).

Two Convocations of the University were held in August 1936—the first one on the 28th August was held for candidates taking second degrees—M.A., L.T., B.L., at which the Vice-Chancellor (Dr. A. Lakshmanaswami Mudaliyar) presided—512 graduates took their degrees; the Second Convocation was held on the 29th August 1936 at which H. E. the Chancellor, Sir Kurma Venkata Reddi (Ag. Governor of Madras), presided. About 1,500 graduates in all the Faculties took their degrees (807 in person and 581 *in absentia*). The address to the Graduates was delivered by Mahamahopadhyaya S. Kuppuswami Sastri, Avl., M.A., I.E.S. (Retd.), now Honorary Professor of Sanskrit, Annamalai University.

The new Buildings of the University—Library, Departmental Building, Botanical Laboratory and Examination Hall — were opened by His Excellency, the Chancellor, on Thursday, the 3rd September 1936.

University of Mysore:

Personnel.—Mr. C. R. Narasimhasastry, M.A., Assistant Professor of Sanskrit, Maharaja's College, Mysore, was appointed Professor of Sanskrit on the retirement of Professor D. Srinivasachar.

Examinations.—The results of the M.A. and M.Sc. degree examinations were published during the month. They were as follows:

Name of Examination	Examined	Passed	
		1st Class	2nd Class
M.A.	13	3	9
M.Sc.	12	3	7 + 1 (not classed)

Convocation.—The 19th Annual Convocation for conferring degrees will be held in Mysore on the 29th October 1936, at 9 A.M. Dr. E. P. Metcalfe, D.Sc. (Lond.), F.Inst.P., Vice-Chancellor of this University, has been nominated to deliver the Convocation Address this year.

Lecture.—The D. Appu Rao Extension Lecture for 1935–36 on 'Co-operation' was delivered by Mr. V. Ramdas Pantulu, B.A., B.L., of Madras at Mysore on the 1st August 1936.

Meeting of the Academic Council.—(i) A meeting of the re-constituted Academic Council was held on the 29th August 1936 at which the following have been elected members of the University Council to be re-constituted as from the 1st November 1936 by and from the Academic Council:

1. Mr. B. K. Narayana Rao, B.A., M.B.C.M., L.R.C.P., M.R.C.S., D.P.H., D.O., Principal, Medical School, Bangalore.
2. Dr. A. Subba Rau, B.A., D.Sc. (Lond.), F.R.M.S., Professor of Physiology, Medical College, Mysore.

(ii) At this meeting the Faculties were constituted by the assignment of the members of Academic Council and the appointment of three teachers to each Faculty.

(iii) Among the decisions arrived at, mention may be made of the following:—

1. Credit of work done during the course in respect of the Intermediate examination.
2. Revision of the course of studies in History for the B.A. Honours Degree examination.

General.—Mr. K. V. Srinath, M.Sc., Lecturer in Botany, Intermediate College, Bangalore, has been awarded the Central State Scholarship tenable in Great Britain for higher studies in Botany during the years 1936–39 by the Government of India, and has left for England.

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